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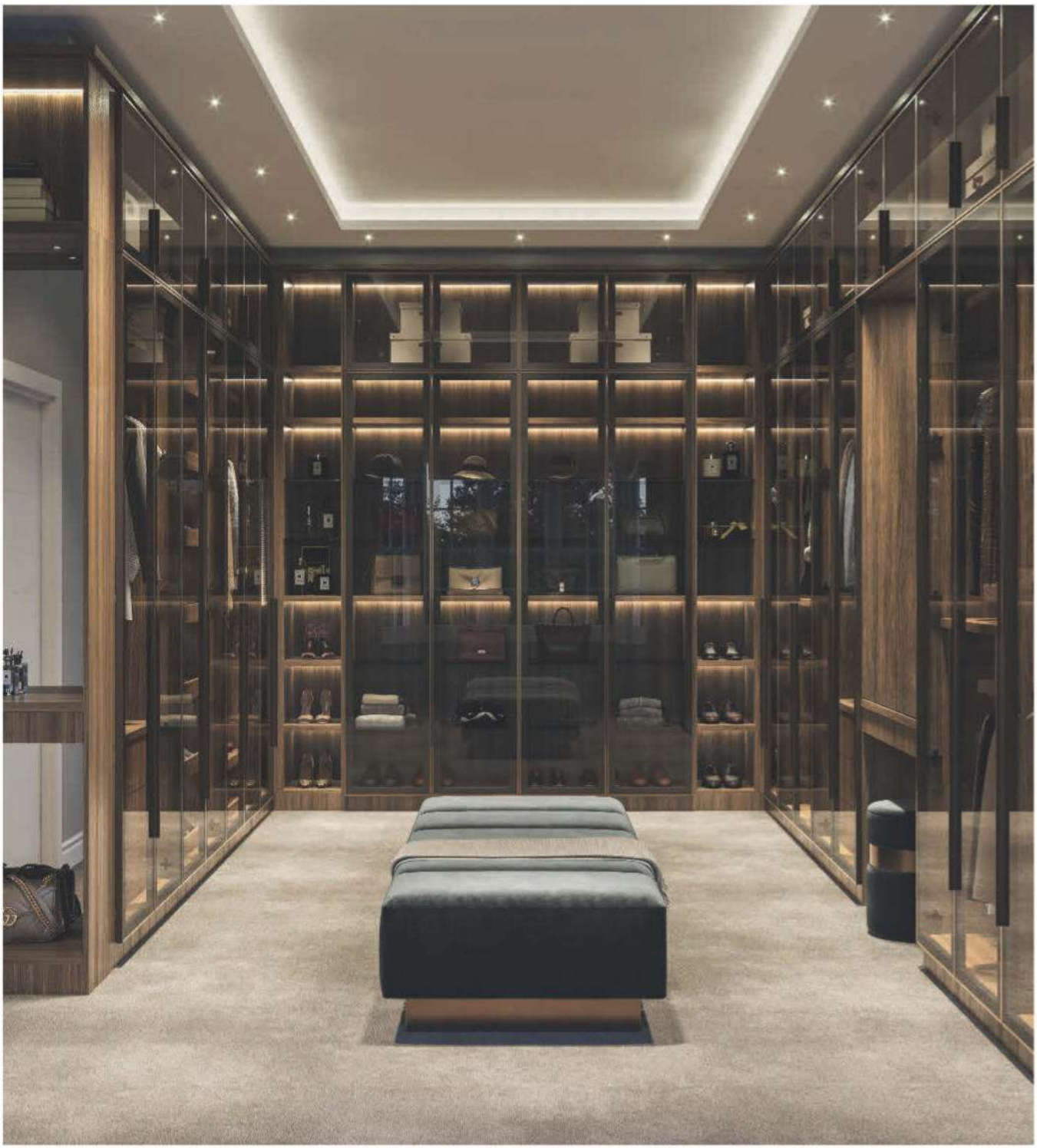

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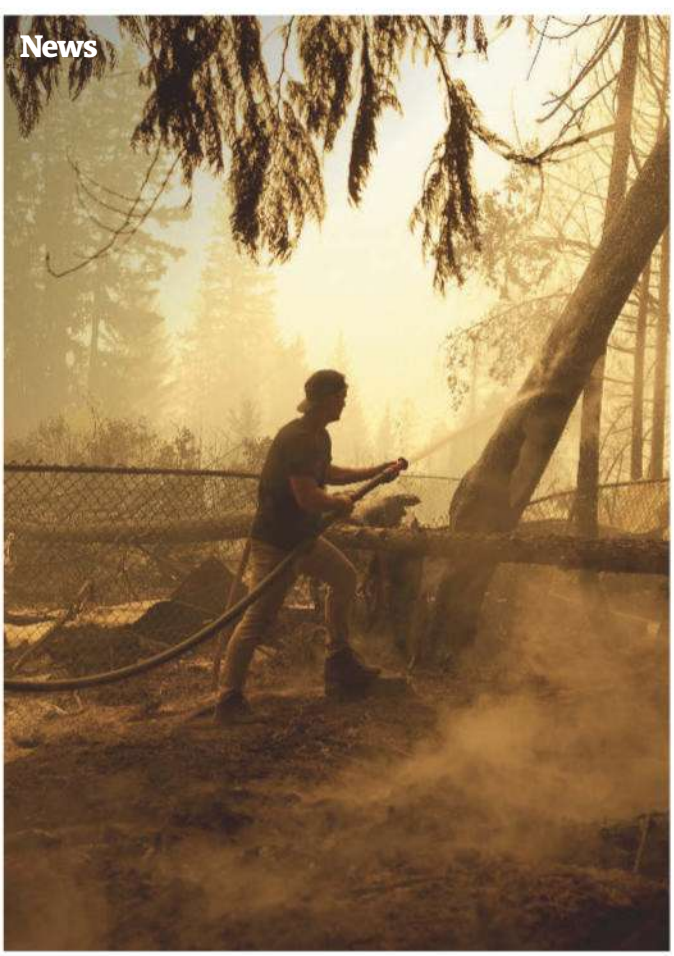

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NS Live

The spooktacular science of baking

Join Josh Smalley, chemistry researcher at the University of Leicester, UK, and finalist of the 2023 series of *The Great British Bake Off*, for a live science extravaganza on 19 October at London's Excel Centre. From the science secrets of pumpkin spice to the molecular mysteries behind our Halloween bakes, watch as Josh delivers a spooky concoction of food demos and science experiments.

newscientist.com/nslive

Tour

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Podcast

The world, the universe and us

The team are joined by Lauri Myllyvirta from the Centre for Research on Energy and Clean Air to discuss China's falling carbon dioxide emissions. They explore a promising norovirus vaccine and learn how passing stars could wreak havoc on our solar system. Plus, they demonstrate the scientific way to slice an onion in order to minimise crying.

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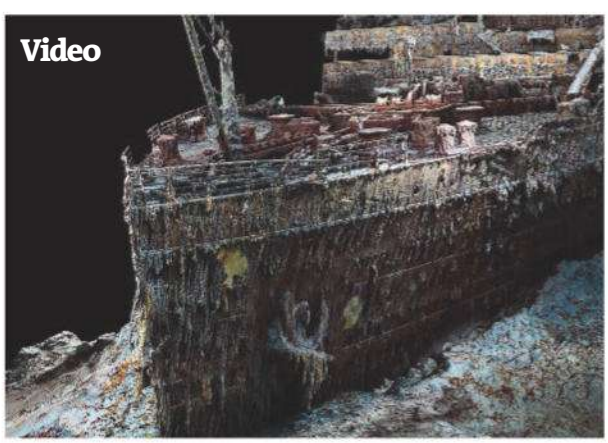
Forest frog Marvel at Madagascar's incredible array of wildlife



Deep-sea dive Explore a "digital twin" of the Titanic

Video

The Titanic's twin

The world's most famous shipwreck, the Titanic, sits around 3800 metres below the surface of the Atlantic Ocean. Its remote location makes the wreck difficult and expensive to study. Now, a team from deep-sea mapping company Magellan has created a "digital twin" of the ship, available to be explored by both researchers and the public.

youtube.com/newscientist

Newsletter

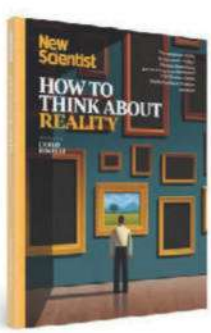
Health Check

Norovirus is a leading cause of vomiting and diarrhoea and affects more than 600 million people each year, costing the world economy billions of dollars. Despite this, we lack an effective vaccine. Reporter Carissa Wong describes a vaccine pill that can prevent infections and may even slow transmission.

newscientist.com/health-check

Podcast

"We've seen it is possible that emissions can fall even as the world's most populous country grows"



How to think...

In the second issue of our new *How to Think About* series, we are diving into the mind-bending concept of reality, with the world's best scientists and philosophers as our guides. Together, we'll explore groundbreaking ideas that bring us closer than ever to unravelling the true nature of the universe.

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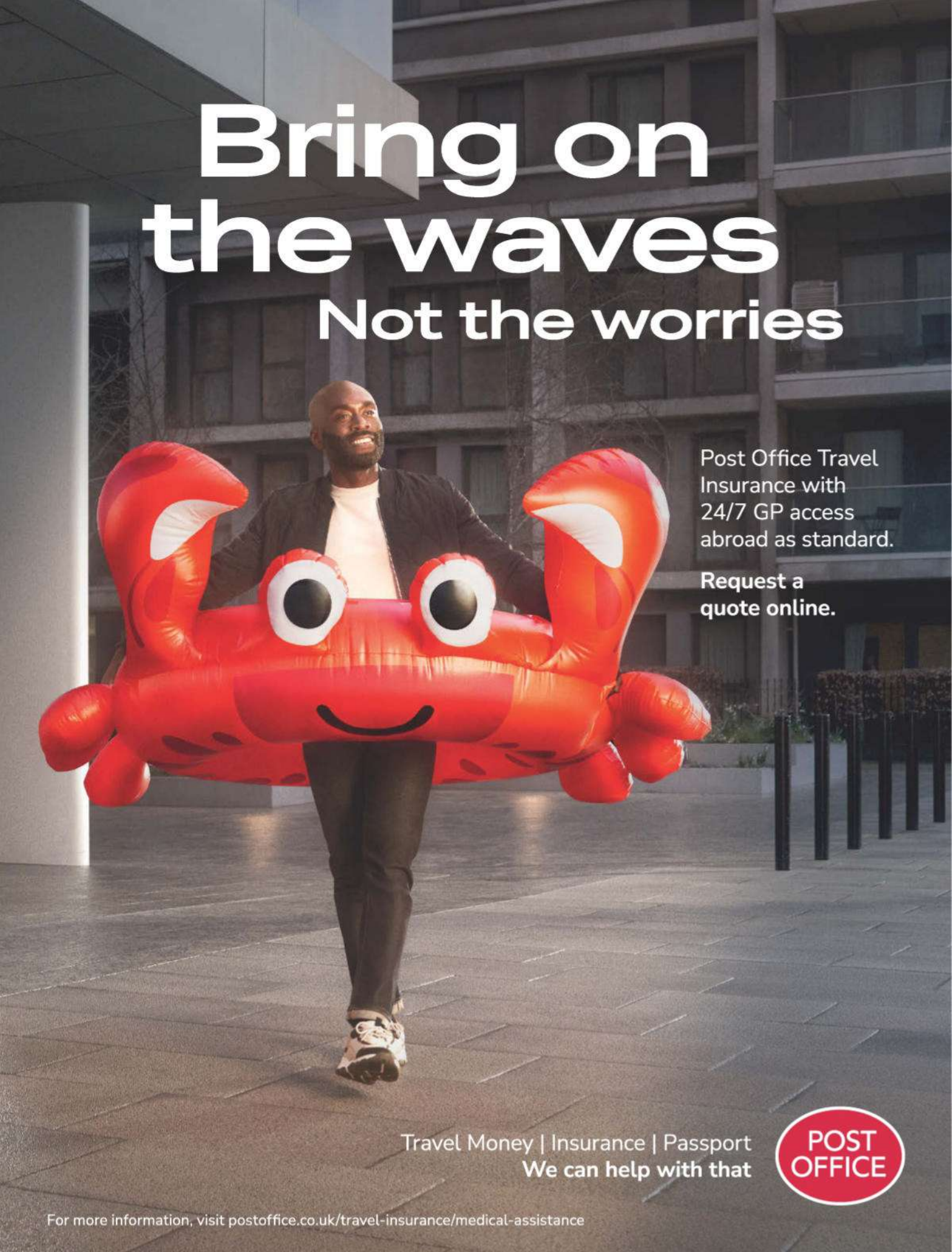
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A shifting climate

With the US in retreat, could China become the next global green leader?

NATURE abhors a vacuum, and so, too, does geopolitics. With the US under Donald Trump vacating the stage when it comes to tackling global warming, the climate crown is waiting to be claimed – and if China's president, Xi Jinping, wants it, it is his for the taking.

China's climate record is mixed. Since 2006, it has been the biggest emitter of greenhouse gases, as the nation has rapidly industrialised. On the other hand, that industrialisation has seen it become the world leader in solar panel manufacturing.

Xi himself has also shied away from the global climate stage. He hasn't attended a COP climate summit since Paris in 2015, when countries agreed a target of holding warming below 1.5°C. While many nations have since interpreted this as needing to reach net-zero emissions by 2050, China has only pledged to reach carbon neutrality, a weaker promise, by 2060.

But that could all be about to change. As we report on page 10, China's emissions appear to have peaked. It also looks like Xi is planning to make an appearance at

"The pieces are falling into place for a major climate intervention from China – but what will it be?"

COP30 when it is held in Belém, Brazil, this November. The pieces are falling into place for a major climate intervention from China – but what will it be?

The most likely announcement is an interim target on the way to 2060, perhaps a pledge for certain cuts by 2040. But if Xi wants to be the world's climate leader, he should go further, with a pledge of net zero by 2050. That this would simply match existing targets by the likes of the UK is no small thing, as there is a feeling in many nations that those who were first to industrialise should also be first to cut emissions. China adopting the 2050 target would make it harder for others to wriggle out of it, and could spur on green tech.

Will Xi go so far? Probably not. But with reports that COP30 may be a disappointment (see page 8), the Brazilian president, Luiz Inácio Lula da Silva, who has made no secret of his desire for strong relations with China, would do well to work on convincing Xi to act. If China is to take the crown, Brazil can be the crown bearer. ▮

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Immerse yourself in science with a short UK break

Mysteries of the universe: Cheshire, England

27 June 2025
3 days

Dive into the mysteries of the universe with an exciting programme that includes a special excursion to Jodrell Bank, home to the iconic Lovell Telescope. Engage with leading astronomers, astrophysicists and cosmologists as they illuminate the latest discoveries in space science, covering topics from galaxy formations to groundbreaking research on black holes.

- Enjoy a series of fascinating lectures that will cover topics from the big bang through to the James Webb Space Telescope
- See images of the southern hemisphere's skies through a remote astronomy demonstration that connects with a telescope in Australia
- Stay in a delightful 4-star hotel in the Cheshire countryside

Human origins and gentle walking in prehistoric south-west England

14 July 2025
5 days

Be immersed in the early human periods of the Neolithic, Bronze and Iron Ages on a gentle walking tour exploring the prehistoric sites of Wiltshire and Dorset. From complex Iron Age hillforts, ancient stone circles and some of the area's most beautiful landscapes, discover this quaint region of south-west England.

- Visit several National Trust, English Heritage and UNESCO listed sites, including Stonehenge, Old Sarum, Avebury and Maiden Castle
- Joined in Cerne Abbas by *New Scientist*'s former editor-in-chief Emily H. Wilson, who will lead a guided walk around this prehistoric landscape
- Enjoy talks from the directors of the Salisbury and Wiltshire Museums offering an insight into what life was like during this period

The science of deep time in the Brecon Beacons

1 September 2025
3 days

Join a gentle walking and talking short break based in the beautiful Brecon Beacons National Park. Witness the cosmic, geological and human forces that have shaped our lives and understand humankind's place in the story of Earth whilst staying at the atmospheric Craig Y Nos Castle. This short break is perfect for those who are fascinated by landscapes, cosmology, palaeontology, geology and astronomy.

- Talks and walking seminars from geologists, astronomers, palaeontologists and deep time advocates
- Venture into one of the UK's deepest cave systems, carved over 300 million years by ancient rivers
- Take part in a guided Deep Time walk through the Brecon Beacons, where every ridge, valley and rock formation tells a story of Earth's ancient past

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News

'Sticky' dark matter
A distant galaxy may house a strange dark substance **p13**

No more norovirus?
Vaccine in a pill could stop you catching vomiting bug **p14**

Taken for a spin
Particles thought to be forbidden by physics may exist **p16**

Coastal concern
Eroding landfills are spilling toxic waste onto beaches **p18**

Take the edge off
An "anti-spice" could make chilli peppers less hot **p19**

NASA/JPL-CALTECH

Technology

Prototype lander breaks the ice

THIS robot may look out of place, but it has been designed with a frozen environment in mind: Europa, Jupiter's icy moon. The prototype lander was put through its paces at Matanuska glacier in Alaska, where it was able to autonomously drill into the ice to collect samples. Europa is enticing to scientists, as it is thought that under its frozen shell is an ocean that could support life.

Climate change

Is the COP30 climate summit in crisis?

Mounting concerns about Brazil's approach to the meeting have observers asking whether it will be able to tackle the difficult choices involved in curbing emissions, reports **Madeleine Cuff**

IT IS now less than six months before the world's nations gather in Brazil for the COP30 climate summit, where observers hope to see key action on halting global warming. But with skyrocketing accommodation prices, distracted world leaders and accusations that the meeting's Brazilian hosts are dodging the difficult topics, is COP30 in trouble?

This year's meeting is particularly important, coming a decade after countries struck the Paris Agreement, the landmark climate deal that pledged to keep warming below 2°C or, ideally, 1.5°C. While the latter goal looks increasingly out of reach (see "Earth is heading for a second year above 1.5°C climate goal", right), the Paris process means all nations are required to submit fresh, more ambitious climate plans this year outlining their strategies to cut emissions up to 2035.

Brazil, then, must play a key role. After a turbulent few years under the presidency of Jair Bolsonaro, a populist who promoted the deforestation of the Amazon rainforest, the choice of the city of Belém – which borders the Amazon – to host COP30 marks a clear change of intent on the part of current President Luiz Inácio Lula da Silva. And with recent COP meetings held in authoritarian nations and petrostates, where freedoms of protest and speech were heavily restricted, expectations are high that Brazil's summit will usher in a new wave of optimism and energy for the climate movement.

"I think COP30 will be an inflection moment," says Stela Herschmann at the Brazilian climate NGO Observatório do Clima. "We are in a tipping point for the science – if we really want to keep the 1.5°C [goal] within reach – we need to accelerate efforts."

DOMINIKA ZARZYCKA/SOPA IMAGES VIA ZUMA PRESS WIRE/ALAMY

The next climate summit starts in six months

2°C
Upper limit to warming, above preindustrial levels, pledged by signatories to the Paris Agreement

2.6°C
Predicted warming above preindustrial levels based on current climate pledges

21
Number of countries that have submitted new climate action plans

But with just months to go before the summit kicks off, that optimism is under threat. Under current climate pledges, warming will escalate to 2.6°C by the end of the century. Campaigners say it is critical that the next round of countries' climate plans – known as nationally determined contributions (NDCs) – ramp up to bring that number closer to the 2°C upper limit set by the Paris Agreement.

Yet nations have so far been slow to come forward with their new action plans. A deadline to deliver new NDCs by early February has passed, and so far just 21 countries have submitted their plans. Major emitters like the European Union – whose 27 member countries produce and submit a joint NDC – and China are yet to deliver. Meanwhile, corporate enthusiasm for climate action appears to be waning, with firms including HSBC, BP, Unilever and Shell watering down their climate goals.

No clear strategy

As the COP30 host, it is Brazil's job to apply pressure to countries and companies to move further and faster on climate. But insiders say there is still no clear strategy for what the Brazilian COP presidency wants out of the summit, with little backroom negotiation underway to press for more motivated NDCs. A series of open letters from the presidency outlining its vision for the summit have been described by observers as vague and abstract, with little in the way of concrete aims for the meeting. The presidency did 't

respond to *New Scientist*'s request for comment.

There is a general sense that Brazil wants to focus on protecting forests and bolstering climate finance for poorer nations. But tougher issues are stuck on the sidelines. Privately, those close to the talks say Brazil seems to be dodging the question of how to accelerate emissions cuts and say the team is seeking to lower expectations for what the summit can achieve. In public, the meeting's CEO Ana Toni said

"We are in a tipping point for the science if we really want to keep the 1.5°C [goal] within reach"

at an event in March that COPs aren't "silver bullets" for climate action, while André Aranha Corrêa do Lago, the summit's president, has told journalists that fresh institutions beyond COP are needed to accelerate the "implementation" of the Paris Agreement.

The other elephant in the room is fossil fuels. At COP28 in Dubai, nations promised the world would "transition away from fossil fuels", but since then, the conversation around how to deliver that transition has barely advanced. Brazil is the world's seventh-largest oil producer, but it also notes in its NDC that it would "welcome" discussion on how a transition away from those fuels would be delivered.

Yet climate campaigners are frustrated that there seems to be no hint of that discussion on the COP30 agenda. "Brazil would be in a very good position to convene an international discussion around phase-out timelines," says Andreas Sieber at international NGO 350.org. He wants to see the issue prioritised ›

Earth is heading for a second year above 1.5°C climate goal

The aim of limiting global warming to no more than 1.5°C is slipping even further out of reach, as the latest climate data reveals global temperatures remain extremely high, with 2025 on course to rival 2024 as the hottest year on record.

April 2025 was the second-warmest April on record, beaten only by April 2024, according to data from both the European Union's climate change service Copernicus and Berkeley Earth, a US non-profit. Global average temperatures for the month remained at 1.51°C above pre-industrial levels, the 21st month in the past 22 to have been above that crucial threshold, according to Copernicus. Berkeley Earth's dataset puts April 2025's average temperature at 1.49°C above pre-industrial levels, cooler than April 2024 by just 0.07°C.

The continuing hot streak has taken scientists by surprise. 2024 was the hottest year on record, with global average temperatures reaching 1.55°C above pre-industrial levels. That was the first time average temperatures had exceeded 1.5°C over a calendar year. Under the 2015 Paris climate accord, countries agreed to limit global temperature rise to below 2°C – and ideally to 1.5°C, a goal that is looking increasingly beyond reach.

Scientists had expected the cooling La Niña weather pattern in January to provide a reprieve, with temperatures expected to fall back a little this year. Instead, they have remained high, increasing fears that 2025 could be the second year in a row above the critical 1.5°C watermark. "The recently ended La Niña event has not provided as much cooling as would typically have been expected," said Robert Rohde at Berkeley Earth during a briefing on 13 May.

According to Berkeley Earth's data, this year now has an 18 per cent chance of being the warmest on record, and a 53 per cent chance of being the second warmest on record, said Rohde. There is a 52 per cent chance of 2025 having average temperatures above 1.5°C.

How the rest of the year unfolds – and what could be in store for global temperatures – now rests largely on whether a new El Niño or La Niña pattern develops in the Pacific, said Rohde.

Hot streak

The continuing hot streak is further eradicating hopes that global temperatures can be limited to the 1.5°C Paris goal. The target is measured over a 20-year average, but researchers are increasingly concerned that the threshold is already breached. "We are inevitably going to cross 1.5°C in the long-term average in the next decade or so," said Rohde.

Last year, scientists warned that three individual years where average temperatures remained above 1.5°C would mean the Paris Agreement target is lost. Similarly, a paper published earlier this year suggested that a run of 12 consecutive months above 1.5°C indicates an 80 per cent likelihood that long-term warming of 1.5°C has already been reached.

Richard Allan at the University of Reading in the UK says he has been surprised at the sustained nature of the warmth. Research over the past two years and the recent record temperatures have shifted scientific opinion on whether limiting warming to 1.5°C is achievable, he says. "Without very massive mitigation over the next 20 years, or a massive volcanic eruption, I think it's inevitable that we have entered the period at which we do cross the 1.5°C above pre-industrial threshold."

But he stresses that the goal of limiting warming to under 2°C is still achievable. "It's still critical that we do aim to keep temperatures below that threshold," he says. MC

This year is shaping up to be another warm one

GUY CORBISHLEY/ALAMY

as part of a final "cover" decision, or become one of the pillars of the opening leader's segment. "So far we have heard hardly anything in that direction from the Brazilians," he says. "I think they shy away from bold leadership so far."

One problem may be domestic politics. Brazil has the left-leaning Lula at its helm, but it also has a conservative Congress agitating for weaker environmental protections and a ministerial team divided on the country's green agenda, says Herschmann. This is "dangerous" for the role of COP presidency, she warns.

HUANG JINGWEN/XINHUA/ALAMY

Chinese President Xi Jinping invited Brazilian President Luiz Inácio Lula da Silva to Beijing earlier this month for a state visit

Global spotlight

Yet among the angst, there are reasons to hope that many nations are about to swing into action. The EU is set to produce a late but aggressive NDC, promising emissions cuts of 90 per cent by 2040. China is positioning itself to take over the role of COP major player from the US, with rumours circulating that President Xi Jinping will attend COP30 in person, his first such summit since COP21 in Paris 10 years ago. If that is the case, a high-aiming NDC from China might be on the cards, such as promising absolute emissions cuts in the region of 20-25 per cent by 2040. That, in turn, could unlock more drive from other nations like India, while guaranteeing the global spotlight for Belém.

Meanwhile, although few NDCs have been forthcoming, those that have emerged are high-quality, says Sieber, featuring targets to drive emissions cuts across various sectors of the economy. "There's a clear quality shift in NDCs," he says. "It means that countries are grappling with how they plan this [transition]".

The economic winds are also blowing in favour of stronger action. Clean energy is attracting double the investment of fossil fuels, while 1 in 5 new cars sold worldwide is now electric. With the direction of travel clear, it becomes easier for a COP presidency to convince countries that more sweeping action makes economic as well as climate sense, especially if development banks and other financing institutions are also on board. COP30 is the last chance for countries to submit new NDCs, so leadership from Brazil in the coming months could make all the difference.

"China is positioning itself to take over the role of COP major player from the US"

The final hurdle for COP30 is the choice of host city. Belém may be the gateway to the Amazon, but it isn't a city well-equipped to handle a conference of 50,000 people. Accommodation prices have soared, intensifying concerns that Indigenous leaders, youth activists and other civil society groups – the very people COP30 promised to welcome – will be priced out of attendance.

Yet for this complication, at least, it seems the Brazilians have a clear plan. An accommodation platform is expected to launch by the end of the month, promising to cater to all budgets. In the interim, green groups have leveraged their global networks to organise group accommodation, while others plan to send smaller teams. Privately, many attendees welcome the opportunity for a slimmed-down COP with fewer lobbyists and side events.

A decade on from the triumph of the Paris Agreement, the world is on the cusp of breaching one of the treaty's central goals. But COP30 must answer the question: where can the climate movement go from here? Time is running out for Brazil to deliver an answer. ▮

China's emissions drop

The world's largest emitter of carbon dioxide, China, has seen a slight decline in those emissions over the past 12 months, even as demand for power has gone up. This is an encouraging sign that the country's massive investment in clean energy has begun to displace fossil fuels – but emissions could still surge again.

That is according to an analysis of China's economic and energy data by Lauri Myllivirta at the Centre for Research on Energy and Clean Air, a research organisation in Finland. The report, published in Carbon Brief, finds that the country's CO2 emissions have declined by 1 per cent over the past 12 months. In the first quarter of 2025 alone, emissions declined by 1.6 per cent relative to last year.

That is mainly a consequence of China's record development of solar, wind and nuclear power, which is beginning to eat into the total electricity generated by burning fossil fuels. A shift away from cement and steel production, which are carbon-intensive industries, have also contributed to the decline.

If China maintains these trends, emissions could continue to fall. A sustained drop would indicate the country has passed peak emissions, putting it several years ahead of its 2030 target.

However, a hot summer could raise demand for electricity-hungry air conditioning and increase emissions. James Dinneen

Cervix-on-a-chip flags potential new treatment for preterm birth

Grace Wade

HUMAN cells have been coaxed into forming a miniature replica of the cervix during pregnancy. This so-called cervix-on-a-chip reveals how inflammation and the vaginal microbiome can contribute to premature birth – and identifies a possible treatment to prevent it.

Premature birth – when a baby is born before 37 weeks of pregnancy – affects more than 13 million infants each year and is the second leading cause of childhood mortality and disability.

Yet there are no effective therapies to slow or prevent it, largely because there are no animals that replicate human pregnancy and labour, making it difficult to study.

Building a cervix

So, Donald Ingber at Harvard University and his colleagues developed a cervix-on-a-chip using cervical cells collected from two women who had their uteruses surgically removed.

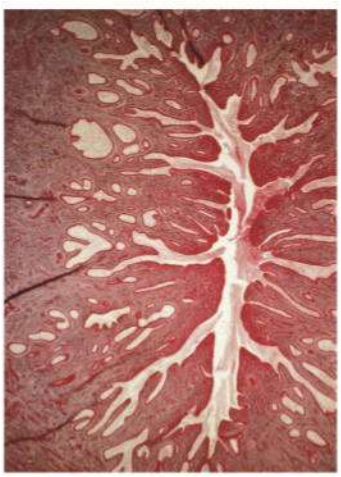
The researchers arranged the cells on a 3D chip in a formation that mimicked the inner cervix's lining and structural layers. They then coaxed the cells to grow and differentiate using a cocktail of hormones and nutrients. Finally, they bathed them in a mix of human hormones equivalent to the levels seen in the early third trimester of pregnancy, when preterm birth most often occurs.

The final model replicated many features of the cervix during pregnancy, including a mucus plug that develops in the cervical canal. This plug typically forms a barrier between the uterus and the vaginal canal, protecting the fetus from infection. During labour, the cervix shortens and the mucus plug dissolves, enabling the baby to pass through the birth canal.

The device has already yielded insights into preterm birth. Because previous research suggested the vaginal microbiome may contribute to this problem, the team applied bacteria resembling either a healthy vaginal microbiome or one commonly seen in bacterial vaginosis infections to six chips each.

After 96 hours, chips with a healthy microbiome saw a roughly 20 per cent increase in a protein essential for mucus formation. By contrast, those with pathogenic bacteria had a weakened mucus plug and a more than 60 per cent increase in a mucus-degrading enzyme, providing further evidence that the vaginal microbiome plays a role in premature birth (bioRxiv, doi.org/pnpb).

Further experiments revealed that immune cells pump out inflammatory molecules in response to pathogenic bacteria. These molecules trigger structural cells in the cervix to undergo changes also seen during delivery, which could explain how the microbiome contributes to premature labour.



OVERSEAS/COLLECTION CNR/SCIENCE PHOTO LIBRARY

A section of a cervix, with the lighter areas showing where mucus is produced

AMELIE-BENOIST/BSIP/ALAMY

More than 13 million infants each year are born premature

The researchers traced these effects to one key inflammatory molecule called interleukin-1 beta. A drug that blocks this inflammatory molecule is already approved to treat rheumatoid arthritis. Applying the drug to four cervix chips led to a roughly 77 per cent decrease in mucus-degrading enzymes, compared with untreated chips. This suggests the therapy could be used to prevent or slow preterm birth.

In addition to flagging a potential new treatment for premature birth, the model has also provided further insight into the factors that trigger labour, says David Relman at Stanford University in California. "Although it's not the first effort to mimic the conditions of the cervix in the laboratory, it is, I would say, clearly the most savvy and effective model that has been created."

Still, it lacks certain cell types and hormones relevant to pregnancy and labour, he says. "Humans are just amazingly complicated. Not only are there many other factors that wouldn't have been incorporated into this model, but those factors are also changing all of the time."

"This provides further evidence that the vaginal microbiome plays a role in premature birth"

This ultimately makes it difficult to know whether these findings apply to premature birth in real people.

"It's not perfect, but you really have to compare it to other models, and there are really no other good models out there" says Ingber. "And the fact that it is human [cells] is, I think, what makes it so relevant." ▮

Quantum computing

A quantum version of Moore's law

The number of qubits at the heart of quantum computers is following a familiar trajectory

Karmela Padavic-Callaghan

THE number of qubits that have been entangled in quantum computers has nearly doubled within the past year – the speed of the increase seems to be following a "quantum Moore's law".

First proposed by Gordon Moore at Intel in 1965, Moore's law states that the power we can get out of a single traditional computer chip doubles at regular intervals; every year at first, then every two years as manufacturing encountered new difficulties. Now, we may be seeing a quantum version of the trend.

To fulfil the promise of solving problems that are intractable for the best conventional supercomputers, quantum computers must include more qubits. But how those qubits are connected to each other matters, especially when it comes to entanglement, a uniquely quantum connection that coordinates their behaviour.

"Entangling more qubits isn't just about breaking records; it's about expanding the frontier of what quantum computers can actually do," says Xiaobo Zhu at the University of Science and Technology of China.

In December 2024, the entanglement record was 50 qubits. But recently, a team led by Haoran Liao at the quantum software firm Q-CTRL combined 75 superconducting qubits into an entangled state called a Greenberger-Horne-Zeilinger (GHZ) state (arXiv, doi.org/pnfp). Around the same time, Zhu and his colleagues entangled 95 qubits within the superconducting Zuchongzhi quantum computer into a "cluster state" (arXiv, doi.org/pnfq). Meanwhile, Ali Javadi-Abhari at IBM and his colleagues created a GHZ state with 120 superconducting qubits.

Quantum computers rely on qubits to store information

UNIVERSITY OF SCIENCE AND TECHNOLOGY OF CHINA

Yuval Baum at Q-CTRL says that entanglement is part of "the secret sauce of quantum computers", but it is also finicky. "It's very hard to create, but it's even harder to maintain," he says.

To make their entangled qubit state stable and reliable, the Q-CTRL researchers used novel methods for both detecting and suppressing errors. All existing quantum computers are prone to errors, so this meant that some runs of the experiment weren't successful – about 80 per cent of the time, the quantum computer detected an error it had not managed to suppress.

Baum says this may sound severe, but it is an improvement on past studies and means that a calculation on the quantum computer would simply take more time because it may have to be repeated. Often, people combat this by adding extra qubits to correct errors – compared with that, this strategy keeps the resources needed to a "rather reasonable" level, says Liao.

IBM's team also used an error detection approach: within a quantum computer with 156 qubits, 120 were entangled and the rest were used to flag when the process went awry.

Thomas Monz at the University of Innsbruck in Austria says that though the numbers of qubits in these experiments are increasingly large, what matters more is how they are used. At the same time, the demonstration of control on these larger quantum systems is progress in itself, he says.

"I think this 'quantum Moore's law' is happening because the entire ecosystem around quantum computing is improving," says Zhu. Advanced software tools such as AI-driven optimisation may even speed it up, he says. ▮

Physics

The secret to chopping onions without crying

IF YOU find yourself crying when chopping onions, physicists have found a possible solution – but chefs probably aren't going to like it.

When onions are cut open, they spray a mixture of sulphur-rich compounds into the air, one of which is syn-propanethial-S-oxide, a chemical that triggers the nerves in the eye responsible for tears.

Sunghwan Jung at Cornell University in New York state and his team used a high-speed camera to analyse the spray made when brown onions are cut with blades of varying thickness and at different speeds.

Using a mounted guillotine consisting of a thin steel blade released from above, Jung and his team sliced a quarter of an onion that had been coated in black spray paint, which helped them track how the onion deformed, and watched the spray with a high-speed camera.

They also used an electron microscope to measure the width of the blade tip, which varied between 5 and 200 millimetres, and changed the height of the blade to adjust the cutting speed, ranging from around 0.4 to 2 metres per second.

The researchers found that sharp blades produced fewer, slower droplets with less energy (arXiv, doi.org/pnfr). When an onion is cut with a dull knife, the blade causes the onion skin to bend, storing elastic energy and building up pressure inside the onion. As a result, when the skin erupts, it does so more explosively, causing some particles to reach speeds of up to 40 metres per second.

A blunt knife can produce as much as 40 times as many droplets as a sharp one, while the fastest speeds produced four times as many particles as the slowest cutting speeds, the team found. Therefore, sharp knives and slow cuts should result in less of the irritating chemicals getting into your eyes – but Jung and his colleagues didn't put this to the test. They declined to discuss the research with *New Scientist*.

"Whether it's really going to change much in the kitchen, it's not obvious to me it's going to be particularly useful," says Anne Juel at the University of Manchester, UK. ▮

Alex Wilkins

"Sharp knives and slow cuts should result in less of the irritating chemicals getting into your eyes"

Cosmology

‘Sticky’ dark matter could be lurking in a distant galaxy

Alex Wilkins

AN UNUSUALLY dense galaxy could be the first clear evidence for the existence of “sticky” dark matter.

In standard cosmology, so-called cold dark matter only interacts with the universe through gravity, which causes it to bunch up in invisible, puffy clouds around galaxies.

But astronomers have found that some of these clouds, called dark halos, appear to bunch together in ways that shouldn’t be possible if dark matter particles can only interact through gravity. One solution is to assume dark matter is “sticky” and able to exert a force on itself beyond that of gravity.

Astronomers have previously found some evidence for this sticky dark matter, but it has been difficult to pin down its location within a galaxy to match with predictions.

Now, Thomas Collett at the University of Portsmouth, UK, and his colleagues have identified a dark halo in a galaxy called SDSS J0946+1006 that appears to be an unusually dense cloud exactly at the galaxy’s centre – just as predicted (*Monthly Notices of the Royal Astronomical Society*, doi.org/pnn3).

The researchers applied a statistical model to measurements taken by the Hubble Space Telescope of SDSS J0946+1006, which acts as a gravitational lens. Such lenses occur when a massive galaxy’s gravity bends the light we observe from other galaxies behind it. The arrangement of the lens allowed the team to calculate how dark matter is distributed in it.

They found that the dark halo is almost certainly near the galaxy’s centre and calculated the gravitational distribution of matter and dark matter, which matches self-interacting dark matter models.

“If the density estimates are accurate, it’s hard to explain with standard cold dark matter,” says Andrew Robertson at the Carnegie Science Center in Pennsylvania. ▮

Psychology

Babies start showing empathy even before they can speak

Giulia Mondaini

WESTEND61/GETTY IMAGES

Empathy is an ancient evolutionary mechanism

CHILDREN between 9 and 18 months old already show empathy, suggesting this ability starts at an earlier age than previously thought, even for babies from different cultural backgrounds.

“If I don’t understand your emotions, I can’t communicate with you and I can’t respond to your emotions, so it’s an essential skill – but we only know how it develops in a small part of the world,” says Carlo Vreden at the Leibniz Institute for Research and Information in Education in Germany.

His team tested empathy in 44 children from rural villages in Uganda and 49 from urban, suburban and rural areas of York in the UK. An adult – either a local researcher or the infant’s mother – simulated pain or discomfort, saying “oooh” and “ouch” as if hurt while rubbing their finger. Researchers then observed the children’s facial expressions and whether they engaged in any comforting behaviours, such as hugging.

Vreden expected to see all the children’s faces reacting, because it is known that babies are already sensitive to emotions at 9 months old. But he says it was unexpected and remarkable that about 9 per cent of the 9-month-old UK infants and about 15 per cent of the Ugandan ones

> **“You could say that the building blocks for empathy are in place at a very young age”**

stroked or hugged their mothers to comfort their pain (*PLoS One*, doi.org/pnnt).

These results suggest empathy begins earlier than previously thought. Prior research suggested clear signs of empathy, like getting upset when seeing someone else in distress, don’t appear until about 12 months old. These behaviours occur more consistently with age, and by 19 months, children respond to others’ distress by soothing them.

Vreden and his colleagues also found an increase in empathy as the children got older. Compared with the 9-month-olds, more than twice as many 18-month-olds comforted their mothers. “You could say that the building blocks for empathy are in place at a very young age, but that it takes them a while to come together, and that some related skills are required to develop first too,” says Vreden.

Empathy is such an ancient evolutionary mechanism, he says, that it didn’t surprise him that it was found in both UK and Ugandan children at the same ages, despite differences in upbringing. Other research shows that in Uganda, parents value obedience and respect for others more, while in the UK, they value autonomy and emotional expressiveness more.

“We’re seeing in both contexts that the kids are responsive to that distress, that they act on behalf of the individual, and I think it’s a really smart and sort of special contribution in the more recent literature,” says Kristen Dunfield at Concordia University in Montreal.

The majority of research on empathy development focuses on children from Europe and North America; very little is known about children in the rest of the world. “If we are only looking at a very small percentage of the world that isn’t actually representative, then we are not capturing human cognition and behaviour at all,” says Vreden.

Such findings are going to “be important in the long term”, says Dunfield, by showing just how empathy, this human tendency to care for one another, develops. ▮

Climate change

US East Coast flood risk rises as key ocean current weakens

James Dinneen

THE slowdown of a major current in the Atlantic Ocean is boosting the sea level and associated flooding in the Northeast US, on top of the already-rising sea level due to climate change. A total collapse of this Atlantic Meridional Overturning Circulation (AMOC) as the planet warms could raise the sea level even further.

"If the AMOC collapsed, this would dramatically increase the flood frequency along the US coast, even in the absence of strong storms," says Liping Zhang at the Geophysical Fluid Dynamics Laboratory of the US National Oceanic and Atmospheric Administration (NOAA) in New Jersey.

Melting ice sheets and warmer water due to human-caused climate change are leading to a rise in average sea level, but the rate of sea-level rise isn't the same everywhere. For instance, some coastal land is sinking, speeding the relative rate of sea-level rise in those areas. Local sea level is also shaped by how heat, water and salt circulate in the ocean, with warmer and fresher water taking up more space than colder, saltier water.

The north-east coast of the US has seen its sea level rising faster than the global average in recent decades. In addition to sinking land, a slowdown in the AMOC – which transports warm water from lower latitudes to the North Atlantic, where it cools, gets saltier and sinks – has long been proposed as a possible driver for this. When this overturning circulation weakens, deep water along the path of the current is expected to warm and expand, sloshing more water onto the shallow continental shelf.

The AMOC naturally varies in strength on different timescales, and climate change has contributed to a slowdown in recent decades as melting ice freshens the North Atlantic and waters there warm. But it wasn't clear whether this slowdown was making a big difference to sea levels.

> "The findings could enable researchers to forecast flooding up to three years in advance"

Zhang and her colleagues used tide gauge measurements along the New England coast to reconstruct the local sea level stretching back more than a century. On top of a steady rise due to climate change, they found a marked pattern of fluctuation between low and high sea levels every few decades. Years with a high sea level aligned closely with years when the AMOC was weak; these years also had more frequent coastal flooding.

The researchers then used two different ocean models to quantify how much fluctuations in the AMOC's strength influenced the local sea level. While the main driver of differences from year to year was the steady rise due to climate change, they found the weakening AMOC substantially boosted sea levels and associated flooding (*Science Advances*, doi.org/pnns). In different parts of the coast, they found that a slowdown in the AMOC was behind 20 to 50 per cent of flooding since 2005.

Because the natural cycles in the AMOC's strength are largely predictable, the findings could enable researchers to forecast which years will see lots of flooding up to three years in advance, says Zhang. This could help make long-term decisions about infrastructure and emergency preparedness.

"It demonstrates that the AMOC really does matter to [sea-level rise]," says Chris Hughes at the University of Liverpool, UK, who wasn't involved in the research. "It's not just there in models or theory; it's actually there in the real world." ▮

NASA EARTH OBSERVATORY/MICHALA GARRISON

Flooding on Long Island, New York, in January 2024

Health

Vaccine in a pill could stop you catching norovirus

Carissa Wong

A NOROVIRUS vaccine pill that cuts the risk of infection could be available in a few years, after it showed promise in a trial where people were intentionally exposed to the virus.

The highly contagious virus infects the stomach and intestines, causing vomiting and diarrhoea that typically resolve within a few days.

Sean Tucker at biotech company Vaxart in San Francisco and his colleagues previously developed an oral vaccine that boosted levels of IgA antibodies that can block norovirus from entering cells.

Now, the researchers have tested this on 141 people aged between 18 and 49, about half of whom took the pill, while the others took a placebo. A month later, all the participants intentionally swallowed a high dose of the GI.1 strain of norovirus in liquid form, while in quarantine. "In the real-world setting, you need 10 to 100 viral particles to be infected, and we use 1 million particles," says Tucker. This helped to ensure enough people got infected, he says.

In the following week, 82 per cent of those in the placebo group became infected, but only 57 per cent of vaccinated participants did (*Science Translational Medicine*, doi.org/pnd4).

"I think most individuals would be interested in taking [the vaccine] if you can reduce your risk by around [25 percentage points] and avoid getting really debilitating symptoms," says Sarah Caddy at Cornell University in Ithaca, New York state, who wasn't involved in the study.

The team also found that vaccinated participants shed substantially less virus in their stool and vomit than those who took the placebo. This suggests the vaccine could slow the spread of the virus, although that needs to be directly tested, says Caddy. ▮

Solar system

Does chaos await the solar system?

Passing stars could pull planets out of alignment and send them hurtling through space

Alex Wilkins

FROM sending Pluto's orbit haywire to forcing Mercury to fly into the sun, stars whizzing by our solar system could cause more havoc than astronomers thought – though the overall risk of these events is still low.

While the orbits of the planets were once considered to be as predictable as clockwork, modern astronomers have found that, on long timescales, they are anything but. This means it is hard to know exactly what will happen to the solar system in the next few billion years, with some simulations showing it could tear itself apart.

The most likely way for this to happen is if Mercury's orbit lines up with Jupiter's, which could see the smaller planet sent hurtling into the sun. Another source of mayhem could come from stars passing close to the sun, within a few solar system widths, but these events are extremely unlikely, with only a 1 per cent chance every billion years.

Now, Sean Raymond at the University of Bordeaux in France and Nathan Kaib at the Planetary Science Institute in Arizona have found that it isn't just rare events like these that can upset our equilibrium – even everyday stellar traffic risks throwing the solar system out of kilter.

"We looked at the typical, run-of-the-mill flybys," says Raymond. "These are the stars that really do pass by the sun all the time, cosmically speaking."

Raymond and Kaib created five simulations, each with different strengths of stellar flybys, and ran each of them 1000 times. Each run had a different starting position for the solar system's eight planets, plus Pluto, and thousands of stars.

There are many potential sources of mayhem in the solar system

TRIFF/SHUTTERSTOCK

The pair found that the overall odds of a planet in the solar system being knocked off course was 50 per cent higher than from internal chaos alone (arXiv, doi.org/pnd3).

"A flyby-driven instability can happen anytime, whereas an internally-driven instability is far more likely to happen 4 to 5 billion years in the future, making flybys the biggest threat to solar system stability for the next 4-plus billion years," says Raymond.

The most surprising potential victim of stellar intruders was Pluto, which Raymond and Kaib found had a 5 per cent chance of becoming unstable. "In no previous study was Pluto ever thought to have any chance at all of becoming unstable," says Raymond, thanks to the calming influence of Neptune's gravity.

They also found that the chances of Mercury being flung into a chaotic orbit, with outcomes such as hitting the sun or knock-on effects for other planets, was 50 to 80 per cent higher than previous estimates, though the absolute risk was small, at 0.6 per cent over the next few billion years. Earth's orbit also has a 0.3 per cent chance of being changed in such a way as to cause significant climate heating, says Raymond.

Dimitri Veras at the University of Warwick, UK, points out that we know the solar system is definitely due a shakeup in 5 billion years, when the sun expands and potentially destroys the inner planets. ▮

Zoology

Capuchin monkeys kidnap another species' infants

IN A first-of-its-kind trend, capuchin monkeys on a remote Panamanian island are abducting howler monkey babies.

The wild population of white-faced capuchins (*Cebus capucinus imitator*) living on Jicarón Island has been monitored with 86 motion cameras since 2017 to capture the sophisticated use of stone tools by the animals to open hard fruits, nuts and shellfish. Five years into recording the footage, in 2022, a researcher noticed one of the young male capuchin monkeys with an infant monkey from another species clinging to its back. This capuchin, nicknamed Joker, picked up at least four baby howler monkeys (*Alouatta palliata coibensis*) over four months, sometimes holding onto them for more than a week.

At first, the researchers thought it was a case of "one individual who maybe is a little weird or a little quirky", says Zoë Goldsborough from the Max Planck Institute of Animal Behavior, who spotted the behaviour.

Then, five months later, four other young male capuchins were found carrying around howler babies. Over 15 months, the capuchin group took in 11 howler babies younger than 4 weeks old (*Current Biology*, DOI: 10.1016/j.cub.2025.03.056).

The behaviour spread around the population through social learning, like a "primate fad or fashion", says Andrew Whiten at the University of St Andrews, UK, who wasn't involved in the study.

"The behaviour spread around the population through social learning, like a primate fad"

While mature female monkeys sometimes adopt abandoned babies of other species, which may be a way to practise caring for their young, the Jicarón monkeys doing this are all immature males, and seem to be actively taking the infants. Why they are doing it isn't clear.

The abducted infants probably die from malnourishment, being too young to survive without their mother's milk. Researchers saw at least three howler infants being carried around even when dead. ▮

Sofia Quaglia

Physics

A new spin on particle physics

Experiments with hydrogen atoms could soon reveal whether particles that were long thought to be forbidden by physics actually do exist, finds **Karmela Padavic-Callaghan**

IF PHOTONS possess more quantum states than expected, it would overhaul our understanding of particle physics – and physicists have now identified a way to test this radical idea in an experiment.

Certain elementary particles have a property called spin. For particles of light, or photons, spin can be in one of two potential states, which manifests as the light being polarised in one of two directions. But what if photons could be in any of an infinite number of spin states, and thus light could have infinitely many possible polarisations?

That would be the case if a photon were a so-called continuous spin particle (CSP), a massless particle that can carry a force and has infinitely many spin states. Physicists long believed that CSPs shouldn't exist; they seemed to be forbidden by the standard model of particle physics, which dictates that force-carrying particles must have a limited number of spin states.

However, more than 10 years ago, Philip Schuster at the SLAC National Accelerator Laboratory in California and his colleagues were inspired to look more closely at CSPs after they tried to prove that there are no exceptions to this restriction on force-carrying particles' spin states – but failed.

"I think we realised, 'Oh crap! People put these particles aside way too quickly'"

"That is what completely changed our thinking. I think we kind of realised, 'Oh, crap! People put these [particles] aside way too quickly'," says Schuster. Now, he and his colleagues have calculated how CSPs could be identified experimentally.

Their work hinges on the massless photon. If it were a CSP, it would have infinitely many spin states and still carry the electromagnetic force. In that case, it would imply that the standard model, which combines all existing particles and their interactions into one internally consistent mathematical theory, is merely an approximation of some more complex model, says Schuster.

He and his team calculated what this would mean for a commonplace physics process: a hydrogen atom emitting a photon as it transitions from a higher to a lower energy state. They found that one specific transition can't emit a single standard photon – but can emit a CSP photon. An experiment that observes that transition could thus prove whether photons are CSPs (arXiv, doi.org/pncr).

Although their mathematical model for the hydrogen atom was simplified, this result still shows that the mathematics of CSPs have matured enough to make contact with the real world, says Schuster.

The idea of CSPs is speculative, but testing it experimentally could lead to impactful results, says Xavier Bekaert at the University of Tours in France. "As [with] other exotic theoretical particles, they could be at the origin of new physics beyond the standard model, and could possibly cure some of the problems faced by the standard model," he says.

"The possibility is kind of radical, and I'm kind of conservative about it," Schuster says. But on the off chance that an experiment does find evidence a photon is a CSP, not only will the standard model have to be retooled, but "a lot of people would eat their hats. I would eat my hat," he says. ▮

Psychology

The most and least satisfying jobs, according to science

AFTER analysing 59,000 people and 263 occupations, scientists have found the most satisfying jobs.

Kätlin Anni at the University of Tartu in Estonia and her colleagues dived into data from the Estonian Biobank, doing what they say is probably the most comprehensive study yet on job satisfaction.

While donating blood for the biobank project, all the participants completed a survey that asked about details of their job, salary, personality and their satisfaction with various aspects of life.

Anni and her colleagues used these details to score the jobs and found that those that seem to give the most fulfilment include clergy, various medical professions and writing. Jobs that appear to make people the least satisfied include working in kitchens, transport, manufacturing and sales.

In terms of overall life satisfaction, rather than just feelings about their careers, being a medical professional, psychologist, special-needs teacher or ships engineer rated highly, unlike being a security guard, waiter, sales worker, carpenter or chemical engineer (PsyArXiv, doi.org/pnf6).

JACKY CHAPMAN/JANINE WIEDEL PHOTOLIBRARY/ALAMY

Being a special-needs teacher ranked highly in terms of job satisfaction

Various factors seemed to contribute to satisfaction, but, perhaps surprisingly, higher income didn't strongly correlate with it, nor did prestige. "I was expecting the job prestige to be more associated with satisfaction, but there was only a slight correlation," says Anni. "Jobs with a higher sense of achievement are associated with higher satisfaction and even lower-prestige jobs can be quite fulfilling."

Low-satisfaction jobs often had a stressful factor, she says – for example, a structured role with a lot of responsibility, like being a manager in a large company. ▮

Chris Simms

Environment

Canada wildfires prevented 2023 being even hotter

Michael Le Page

JESSE WINTER/BLOOMBERG VIA GETTY IMAGES

A wildfire in Kamloops, British Columbia, Canada, in July 2023

2023 smashed the record for the hottest year, but it could have been worse. The entire northern hemisphere would have been nearly 1°C warmer on average during its summer without the cooling effect of smoke from massive wildfires that hit Canada.

"I think it's really hard to comprehend how gigantic the fires were. It was insane," says Iulian-Alin Rosu at the Technical University of Crete in Greece, who presented his team's findings at a meeting of the European Geosciences Union in Vienna, Austria.

The emissions were around five or six times higher than those during any previously recorded wildfire season in Canada, estimates Rosu. The carbon dioxide from these fires is having an ongoing warming effect, but in 2023 this warming was outweighed by the cooling effect of smoke blocking sunlight.

To estimate how much cooling the smoke caused, Rosu and his colleagues ran a series of climate model simulations with and without the Canadian wildfire emissions. The results suggest that between May and September, the smoke caused local cooling of as much as 5.4°C (9.7°F) in small parts of Canada, and that the northern hemisphere as a whole was 0.9°C (1.6°F) cooler (EGU General Assembly 2025, doi.org/pm79).

This may seem surprising given that parts of Canada saw record temperatures during that summer. But the heat records were mostly in western regions, says Rosu, whereas the smoke blew east and had the biggest cooling effect on that side of the country.

The impacts weren't limited to Canada. In the model, the wildfire emissions led to changes in winds over Asia that weakened the monsoon and led to less rainfall in India – and that is what happened in reality.

However, the cooling effect didn't last long. "When I looked at the data for November and December, there really wasn't much of any effect left," says Rosu.

The record set in 2023 for hottest year didn't last long either – 2024 turned out to be even hotter. ▮

Health

Device tracks milk intake during breastfeeding

Carissa Wong

PARENTS could one day measure how much breast milk their baby is drinking, thanks to a device that sends alerts to their smartphones in real time.

"A common anxiety around breastfeeding is the uncertainty surrounding the amounts of breast milk that babies get," says Daniel Robinson at Northwestern University in Illinois. "It increases stress for the breastfeeding mothers, parents and even the clinicians." Undernourished infants may grow less quickly and, in extreme cases, can become dehydrated.

Clinicians often assess how well infants breastfeed by weighing them before and after a feed, and reviewing how frequently they fill diapers, but these are crude measures, says Robinson.

To develop a more precise metric, he and his colleagues built a device made up of four electrodes, each a few centimetres wide, that can stick to the breast, away from the nipple. Two electrodes transmit very weak electrical currents from one side of the breast to the other, where they are received by the second pair.

The device sends these recordings to a smartphone app that calculates how much milk has been released in real time, based on the electrical signals becoming weaker as more milk is released, says Robinson.

The device is made of four electrodes, a few centimetres wide

NORTHWESTERN UNIVERSITY

To test the validity of the system, the researchers asked 12 breastfeeding women to try the device while they used breast pumps to express into bottles for about 15 minutes. The system estimated the volume of milk collected to within about 2 millilitres of the actual amount, on average (*Nature Biomedical Engineering*, doi.org/pm8g).

This suggests the device could enable parents, under the supervision of clinicians, to track their babies' nutrition and make appropriate changes, such as potentially supplementing with formula milk, says Robinson.

"A common anxiety with breastfeeding is the uncertainty around how much milk babies get"

In another experiment, one of the women wore the device while breastfeeding. The app calculated that her baby drank 24 millilitres of milk, which is similar to the 20 millimetres the team calculated by weighing the infant immediately before and after feeding, says Robinson.

"One of the commonest reasons for mothers with term infants giving up breastfeeding is the perception that they have insufficient milk, so this technique could be helpful in establishing whether that is true or not, and also maybe to see if changing positioning or latching could improve milk flow," says Mary Fewtrell at University College London.

But larger studies are needed to verify the accuracy of the approach, whether the device interferes with milk production, has any long-term side effects and if parents even want it, says Amy Brown at Swansea University in the UK. ▮

Space

The moon's insides may be lopsided

Karmela Padavic-Callaghan

JPL/NASA

The moon's near side is hotter underneath the surface than the far side

EARTH'S gravitational pull on the moon has revealed that our satellite's interior is warmer on its near side, the one facing our planet, suggesting its insides are uneven.

We have known that the moon's near side looks different from its far side since we first began observing it. But we haven't been sure whether that difference reflects something quite literally deeper – something under the moon's surface, says Ryan Park at NASA's Jet Propulsion Laboratory in California. He and his colleagues have now used data from NASA's GRAIL spacecraft to show it does.

In the GRAIL mission, two spacecraft orbited the moon in 2011 and 2012 while collecting data on how the moon's gravity affected their respective motion. Because its gravitational field reflects its physical features, this let researchers calculate the moon's shape and how it is deformed by the tidal pull of Earth.

But the details of this gravitational field couldn't be explained by just the outer lunar appearance – researchers had to consider whether the interior could be uneven. Past studies predicted that the moon's near side would deform more than its far side in response to Earth's pull, says Jeffrey Andrews-Hanna at the University of Arizona. The new work confirms that and "provides a new look into the interior of the moon", he says.

Park and his team used the GRAIL data to precisely calculate how susceptible the moon is to changing shape in response to Earth's gravity. They found that this measure is 72 per cent larger than it would be if the moon's interior were perfectly even and symmetrical.

The team explored different reasons for this anomaly, but the model that best matched the measurements was one where the near side of the moon's interior is warmer than its far side: a lopsided temperature distribution (*Nature*, doi.org/pm6v).

How exactly the moon ended up this way remains an open question, though some of its uneven interior may be due to a history of collisions with other objects, says Park. ▮

Environment

Toxic waste threatens eroding coasts

Michael Le Page

TO THE already very long list of problems caused by global warming, add toxic waste in old landfills becoming exposed by coastal erosion and spilling out to pollute beaches and seas.

"There is not lots of toxic waste spilling out at the moment, but there will be in the future," says Andrew Russell at Queen Mary University of London.

The average global sea level has already risen by around 0.3 metres due to global warming and will keep on rising for centuries – even if net zero is achieved – probably by many metres.

This is speeding up the erosion of coasts, especially where the shore consists of soft materials, for example in East Anglia in the UK.

Team member Kate Spencer, also at Queen Mary, discovered a few years ago that the contents of some landfill sites near the coast were spilling out, so got together with Russell and others to investigate.

"There is not lots of toxic waste spilling out at the moment, but there will be in the future"

In Britain alone, the team has now identified more than 1000 old landfill sites at risk, Russell told a recent meeting of the European Geosciences Union in Vienna, Austria (EGU General Assembly 2025, doi.org/pnd5).

"There were no regulations, no one knows what's in them, how big they are, but we've found medical waste, old cadmium batteries, asbestos, just falling out of the frontage onto the beach," he told *New Scientist* afterwards.

"My understanding is [that] around London, you would throw all your rubbish onto a barge, go up to Essex, dig a hole, throw it in, cover it up and then leave it there."

The problem isn't just limited to the UK. The team is collaborating with researchers in France on a similar project, and Russell was told this is also an issue in Italy after his talk.

An emerging issue

Nor is this limited to landfills. In New Zealand, for instance, toxic waste from an aluminium smelter could be released by coastal erosion.

However, it is unclear just how big the problem is. "It's an emerging issue," says Russell.

Where old landfill sites contain only things such as construction debris, they could just be left to erode. This will create an unsightly mess, but wouldn't be a major threat to people visiting beaches or to marine ecosystems.

If sites contain large amounts of toxic waste, however, the only solution might be to concrete them over to keep it contained, says Russell.

Government agencies in the UK don't seem to want to get to grips with the issue, he says. "They're overworked. They don't want a new problem to deal with. Maybe that's unfair, but if I was in their position, I would be reluctant to open this can of worms."

"We are committed to supporting coastal communities and making sure flood risk management is fit for the challenges we face now and in the future," says a spokesperson for the UK's Department for Environment, Food and Rural Affairs. ▮

Health

Baby with rare condition receives world-first personalised gene therapy

A CHILD with a life-threatening genetic condition has become the first person to receive a bespoke CRISPR gene-editing treatment, giving a glimpse into what the future of medicine might hold.

It is the first time anyone has been given a gene-editing treatment designed to correct a disease-causing mutation found only in them, Rebecca Ahrens-Nicklas at the Children's Hospital of Philadelphia, Pennsylvania, told a press briefing.

"He's showing some early signs of benefit," she says, but it is too soon to tell how well it worked.

The team published the details of the case as soon as possible, in the hope it would inspire others, says Kiran Musunuru at the University of Pennsylvania.

"I don't think I'm exaggerating when I say that this is the future of medicine," he says. "This is the first step towards the use of gene-editing therapies to treat a wide variety of rare genetic disorders for which there are actually very few treatments currently in development at all."

The boy, KJ, inherited mutations in each of his two copies of a gene for a liver enzyme called CPS1. Without this enzyme, ammonia builds up in the blood when proteins, including ones we eat, are broken down, damaging the brain. More than half of children born with a CPS1 deficiency die in early infancy, says Ahrens-Nicklas.

She and Musunuru have been developing treatments targeting the liver for this kind of disorder, allowing them to rapidly create a base-editing therapy – a form of CRISPR – that corrects one of KJ's two copies of the *CPS1* gene.

The team contacted US regulators early on. "KJ was very, very sick, and there wasn't time for business as usual," says Musunuru. "When we formally submitted our application to the FDA [Food and Drug Administration] when KJ was 6 months of age, the FDA approved it in just one week."

KJ was given a low dose in February 2025 when he was 6 months old, followed by larger doses in March and April. He is now able to eat more protein, despite taking lower amounts of other medications to manage his condition (*New England Journal of Medicine*, doi.org/g9j95r).

Ideally, children would be treated earlier to prevent the long-term damage such conditions can cause. As *New Scientist* reported last year, Musunuru's aim is to one day edit human genes before birth.

Other gene-editing therapies are designed to work for many people, regardless of the specific mutation causing their condition. For instance, the first ever gene-editing treatment, for sickle cell disease, works by turning on production of fetal haemoglobin, rather than by correcting the underlying mutations in adult haemoglobin. Despite being a "one-size-fits-all" treatment, it still costs £1,651,000 in England.

Personalised treatments are likely to be even more expensive. Musunuru says he can't put a number on KJ's treatment as the companies involved did much of the work for free. But he expects the price to come down in time. ▮ MLP

Kiran Musunuru and Rebecca Ahrens-Nicklas with patient KJ

CHILDREN'S HOSPITAL OF PHILADELPHIA

Chemistry

'Anti-spice' could be used to make chilli peppers less hot

ACCIDENTALLY made your food too spicy? One day, you might be able to reach for an "anti-spice" condiment to tame the heat of a dish.

A chilli's potency comes from compounds called capsaicinoids, which bind to receptors on nerve fibres within your mouth, sending impulses to the brain that create a burning sensation.

The Scoville scale measures the heat of a chilli based on the concentration of capsaicinoids, yet some varieties aren't as hot as their rating suggests. To investigate, Devin Peterson at the Ohio State University and his colleagues used an analytical method known as liquid chromatography-mass spectrometry to determine exactly how much dihydrocapsaicin and capsaicin – two types of capsaicinoids – were in powdered samples of 10 types of peppers.

Then they gave samples of tomato juice containing powder from the different chillis to a panel of tasters. The samples should have all had a relatively mild kick of 800 Scoville units. But the tasters perceived the heat from the peppers as different. Additional analyses identified three compounds – capsianoside I, roseoside and gingerglycolipid A – that were present in high quantities in the chillies that weren't as intense as they should have been.

Scotch bonnet is one of the spiciest chilli pepppers

SHUTTERSTOCK/ALTIN OSMANAJ

A group of 37 tasters then tested two samples at once, one with these three compounds and one without, placed on either side of their tongue to stop an inflamed tongue affecting a second taste test. The compounds decreased the chilli intensity by between 0.7 and 1.2 points on a 15-point scale, on average (*Journal of Agricultural and Food Chemistry*, doi.org/g9j5p6).

"They are effectively anti-spice compounds," says Peterson. Using them could enable the creation of a household ingredient to tone down excessive heat in dishes, he says. ▮ **Chris Simms**

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Comment

Avoiding Armageddon

We have been lucky to dodge nuclear war so far, but we can't keep trusting to fortune. This is what we must do instead, says **Mark Lynas**

ELAINE KNOX

THE good news is that we might be about to solve the Fermi paradox. Many have long suspected that the reason why there don't seem to be millions of talkative aliens out there in space is that, when an intelligent civilisation develops the technology to enable interstellar communication, it also develops weapons that enable it to quickly destroy itself.

So far, we are matching this trajectory. We have sent probes beyond the solar system – and vast quantities of electronic data fizzing in all directions at the speed of light – but we have also got thousands of thermonuclear weapons on hair-trigger alert that can reduce our entire world to a dark, freezing wasteland.

Whether or not we can avoid this doomsday outcome is perhaps the ultimate test of our species-level intelligence. But the omens aren't good. Russia and the US each have around 1500 fully deployed nuclear warheads and more than 5000 in their total arsenals. China is racing to reach nuclear parity by 2030. The current geopolitical instability raises the risk of world war to perhaps its greatest level since the hottest periods of the cold war.

Due to its "launch-on-warning" posture, the US requires its intercontinental ballistic missiles to be out of their silos and in the air while an incoming nuclear salvo is still blips on a radar screen. Once launched, these missiles cannot be recalled, nor can their targets be altered. If a warning of imminent attack is received, the US president has as little as 6 minutes to decide whether to launch an all-out retaliation that would destroy most life on Earth.

A major thermonuclear exchange would be likely to kill about 770 million people in blasts and city firestorms. Many more would quickly die from radiation poisoning, but the biggest killer would come after: a decade-long nuclear winter that would starve billions more to death and wreck our civilisation beyond repair.

The probability of nuclear war in any single year is small, probably around 1 per cent, but this compounds to a two-thirds risk over a century. We have been lucky with past near misses, from the Cuban Missile Crisis in 1962 to the notorious "3am phone call" in 1979, when US President Jimmy Carter was nearly woken in the night because 2200 incoming Soviet missiles were erroneously displayed on warning screens.

We would be unwise to trust to luck forever. It should be obvious that nuclear weapons and human civilisation cannot co-exist long term. Either we abolish them or they abolish us. To do so, we must build a citizens' movement focused on the goal of total abolition. This will need to be very different from earlier anti-nuclear movements: we can learn from the successes and failures of the Campaign for Nuclear Disarmament and other previous efforts. Nor is it about abolishing nuclear energy, which is vital for tackling the climate crisis and can even help remove warheads by burning them up as fuel.

We can't be unilateralist either, because the process can only work via simultaneous, trust-building disarmament by all the nuclear nations. This movement must involve millions of people in every country whose only reason for participation is that they want to survive. We have a good head start in 2017's UN Treaty on the Prohibition of Nuclear Weapons, already signed by 94 countries, almost half the world's nations.

This should be an easy decision for countries. Collective suicide is in nobody's interest. We don't need weapons that could burn millions alive and usher in a nuclear winter. But the first step is to break free of the fatalistic denial that views nuclear weapons as inevitable and their abolition as impossible. That way the Fermi paradox can be sidestepped and we can continue to flourish on our beautiful, living planet. ▮

Mark Lynas is author of *Six Minutes to Winter: Nuclear war and how to avoid it*

No planet B

Car wars

Car wars A huge hike in parking costs in my home of York has provoked outrage. This may sound like a local problem, but reducing car use is an issue for all of us, says **Graham Lawton**

Graham Lawton is a staff writer at *New Scientist* and author of *Mustn't Grumble: The surprising science of everyday ailments*. You can follow him @grahamlawton

Graham's week

What I'm reading
I'm preparing to interview a big-name author, so her new book, mostly.

What I'm watching
Climate dystopia drama Families Like Ours *on BBC iPlayer.*

What I'm working on
See above.

This column appears monthly. Up next week: Annalee Newitz

THERE is a hardware store on my local high street renowned not just for its excellent and reasonably priced products, but also for the witty messages written on a chalkboard by its entrance. Right now, it reads, "500% increase in parking tariffs; Trump jealous".

This is probably lost on anyone who doesn't live in York, UK, but will be recognisable (and funny) to anyone who does. It refers to a controversy that has become the talk of the town, and could turn out to be a test case for any city in the world with a traffic congestion and air pollution problem – which is pretty much everywhere. A few weeks ago, the local council hiked the cost of the car park nearest the store by roughly 500 per cent. It used to charge 80 pence per hour. It is now £4.85 an hour, rising to £5.30 on Fridays and Saturdays. The cost of using other city-centre car parks has been raised to the same amount, albeit from a higher starting point.

The council has justified the steep rise on the grounds that York has a congestion problem, and also for environmental reasons. The city's air quality is bad. Reducing car use would also cut carbon emissions. York's climate change strategy calls for a 20 per cent reduction in car miles by 2030.

Cue a predictable furore. A petition against the increase has been signed over 8000 times; the local paper is full of angry letters. Less hysterically, traders are worried they will lose business and even go under, which would be a crying shame. The high street near me is thriving and packed with independent shops and restaurants. In 2015, it was voted Great British High Street of the Year.

The local councillor copping all the flak is executive member for transport Kate Ravilious, who also happens to be a science writer and a contributor to *New Scientist*. In a combative radio interview, she pointed out that 1 in 4 households in York don't have access to a car and rely on buses, which are usually stuck in traffic. Businesses are already affected by late deliveries, she said. The city is growing and the council is committed to tackling congestion and pollution.

The row reminds me of similar spats in London over the imposition of the congestion charge in 2003 and the expansions of the Ultra Low Emission Zone in 2021 and 2023. Both were vociferously opposed by the car lobby and many drivers, who falsely claim that there is a "war on motorists" and that they are always used as a cash cow by local government.

> **"A review found that increasing parking costs leads to a reduction in car ownership and better air quality"**

The opposite is true. Recent research in Germany found that car owners don't pay the full cost to society of their pollution, noise and accident risk. In fact, the taxpayer picks up 41 per cent of the total. We all subsidise car owners, not the other way round.

I asked Ravilious how the council arrived at the decision. She told me that it drew on various lines of evidence, including what happened when it last increased parking charges, which was by 15 per cent in 2023. That hike led to a 5 per cent decrease in car park use, but no reduction in visits to the city centre. In fact, footfall on two of the main shopping streets rose by 7 per cent.

The council also looked at two other UK cities, Oxford and Edinburgh, which have experimented with large increases in car park prices too. "Their cities have not suffered economic decline," Ravilious told me. "In fact, the reverse has happened."

The final piece of evidence was a 2023 review commissioned by the Scottish government on how parking policy might help it achieve its target of a 20 per cent reduction in car use by 2030. Using evidence from the UK and abroad, the review found that increasing parking costs leads to a reduction in total distance travelled by car, a reduction in car ownership, increased use of other forms of transport and improved air quality.

I am on the council's side, but evidence doesn't win arguments like this. "It has become very, very emotive," Ravilious told me. "There's plenty of evidence, but there's also politics and emotion. And once emotion takes hold, it tends to win out over evidence." There are rumours the council will back down. I say, hold your nerve and give the world more evidence that car use can be curbed.

Speaking of holding your nerve, a few months ago I wrote about an impending court decision with huge implications for the UK's marine protected areas. In a nutshell, the European Union challenged the UK's decision to close its sand-eel fisheries to protect various endangered seabirds, including puffins. A win for the EU would have led to the UK's entire marine conservation strategy effectively being declared null and void. The court announced its final, non-negotiable decision earlier this month. The UK largely won, and the ban will stay. ▮

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Fragile home

Earth Photo 2025
Royal Geographical Society

THESE images from the Earth Photo 2025 competition shortlist tell revealing, inspiring and unexpected stories about the climate and life on our planet.

At far top left, photographer Ami Vitale's image *Pandamonium* shows a giant panda keeper checking the health of a panda cub in the Wolong National Nature Reserve in Sichuan province, China. The keeper's outfit is part of an effort to reduce the impact of human contact on the bears. Next, clockwise, is Sue Flood's *Crabeater Seals*, shot on an ice floe in the Southern Ocean, off the Antarctic Peninsula. For Flood, such photos can bring the region's wonder to those who may never visit.

Paradise to Ashes, La Palma by Jonathan Browning shows the aftermath of the 2021 Cumbre Vieja volcanic eruption on this island in the Canaries, Spain. A woman has remade her garden, removing lava that destroyed mature palms and replacing them with new trees.

The final image is Vincenzo Montefinese's *Lost Oases*, shot in Tinzouline, Draa valley, Morocco. Here, a man adjusts a solar panel that powers a water pump that irrigates nearby palm groves. Climate change and water use have shrunk the valley's oases by two-thirds over the past century. Today, farmers must dig more wells, often illegally, to access groundwater.

The photos and videos on the shortlist were chosen by a panel including *New Scientist* picture editor Tim Boddy and head of editorial video, David Stock. The winners will be revealed on 16 June. The Earth Photo 2025 exhibition is at London's Royal Geographical Society from 17 June to 20 August before it tours the UK.

Liz Else

Growing pains

Most parenting manuals end up gathering dust on my bedside table, but this science-backed guide to raising kids isn't one of them, says **Catherine de Lange**

Book

Hello, Cruel World!

Melinda Wenner Moyer

Headline Home (UK); G.P. Putnam's Sons (US)

THE unfortunate thing about parenting books is that, in my experience, once you become a parent you are too time-poor and exhausted to read them. As a result, my bedside table is stacked with parenting manuals of which I've read the first five pages a dozen times before passing out.

If this sounds like you, the latest book by science journalist Melinda Wenner Moyer should be top of your pile. *Hello, Cruel World!: Science-based strategies for raising terrific kids in terrifying times* is designed as a research-backed guide to help parents equip their children with the tools they need to thrive.

I should say upfront that I am a fan of Moyer's. Her first book, *How to Raise Kids Who Aren't Assholes*, is of course sitting unread at the top of my bedside pile, but I do subscribe to her Substack, *Now What*, which I love for her non-judgemental, evidence-based approach to parenting.

One of a child's most important jobs is to make sense of the world

This book offers more of the same. The chapters are short and readable, broken down into bite-sized sections, each giving you one piece of advice and the science to back it up. Moyer oozes empathy and can help you take a kid's-eye view on even their most infuriating behaviours.

Take, for instance, the challenge of raising kids in a world of political polarisation. How can we get them to be more open, unbiased and willing to consider other viewpoints? One way is to encourage curiosity and uncertainty from a young age. Children, as we know, are like young scientists. "One of their most important jobs is to make sense of the world around them," writes Moyer. This curiosity can often clash with an adult's desire to get things done. "When you ask your child to clean their room, then find them thirty minutes later studying a spider in the bathroom... it's easy to dismiss their behavior as disobedience. But the underlying reasons for their distraction may be biological, benevolent, and evolutionary adaptive," she writes.

So, says Moyer, we need to respond to these (extremely frustrating) sorts of behaviours

"I put Moyer's advice into practice as my blood boils after asking my son five times to get his homework out"

with empathy and support rather than a rollocking. I put this into practice when, as my blood is boiling after asking my son five times to get his homework out, I find him lounging on the kitchen floor pressing both pedals of the dustbin on repeat.

When I ask him what he's up to, he tells me he wants to see whether one half of the bin closes faster than the other. "What did you discover?" I ask, biting my tongue. "One closes faster than the other!" he replies. I ask him why that might be so. "I'm not sure, maybe one has more friction than the other?" And I have to admit Moyer might be on to something.

The chapters on gender stereotypes are particularly good, shedding light on the ways our behaviours as parents tacitly reinforce societal expectations of girls, but the issue I was most interested to get Moyer's take on was technology, especially mobile phones and social media. Parents at the school gate are extremely worried about their effects on kids, thanks in part to the techno-panic driven by books like Jonathan Haidt's *The Anxious Generation*. Here, Moyer brings her common-sense approach once more, picking apart much of the research cited by Haidt and others. As for access to phones and social media, Moyer has useful advice on how to decide when the time is right, and if you do take the plunge, how to set up healthy habits.

My only gripe, and it is a small one, would be the chapter on substance use, which takes a hard line "just say no" approach. It may be my European sensibilities, but the research here feels weaker than elsewhere, and seems to contradict findings from other parts of the book, which tend to refute outright restriction. Of all the issues facing kids today, the one that really keeps me up at night is the future state of the climate, so I would have rather had a chunky chapter on that instead. Perhaps it will be in the next book.

By Moyer's own admission, she covers so much ground that entire books have been written on most of the topics she spends a chapter on, so her coverage may feel a bit "lite" to some. But I appreciate it for its bite-size chapters and friendly tone – it is one book that won't end up gathering dust on your nightstand. ▮

CAVAN IMAGES/ALAMY

Don't believe the hype

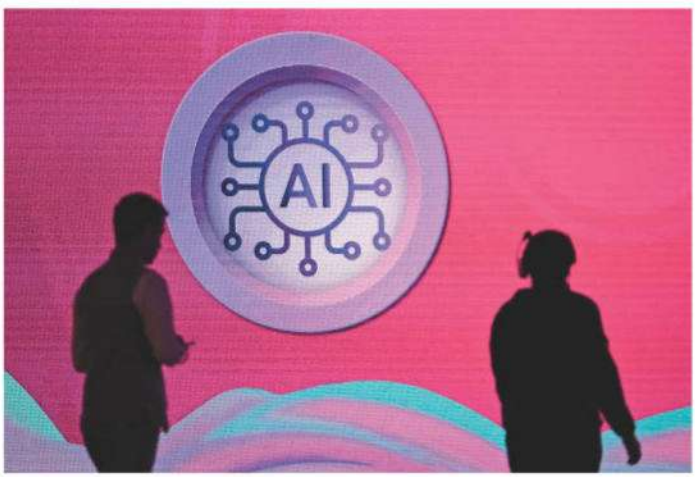
A new book attempts to puncture the artificial intelligence bubble, but it is frustratingly one-sided, finds **Alex Wilkins**

Book

The AI Con

Emily Bender and Alex Hanna

Bodley Head (UK); Harper (US)



INDRANIL ADITYA/MIDDLE EAST IMAGES/AFP VIA GETTY IMAGES

AI takes centre stage at the World Audio Visual Entertainment Summit in Mumbai, India

AN ALTERNATIVE history of Silicon Valley can be told not through its successes – products like the iPhone, Facebook or Google – but through its scams, like Theranos's faulty blood tests or FTX's dodgy crypto accounts. From a bird's eye view, these companies' stories share a formula: invent a world-changing idea, generate hype, convince investors of potential, and then expand as far and fast as possible. But under closer scrutiny, the hype can falter – and quickly unravel.

It is that scrutiny that today's AI industry desperately needs, argue Emily Bender and Alex Hanna in their new book *The AI Con: How to fight big tech's hype and create the future we want*. In their telling, we have been massively oversold on the capabilities of these systems, and the hype generated by large AI companies is so vast and all-consuming that it threatens genuine societal harm in its wake.

If you have paid any attention to the many downsides of AI in recent years, then much of the evidence presented in the book won't seem new: systemic biases, intellectual property theft and overhyped claims that fail to be replicated. Yet, Bender and Hanna write, the AI bubble continues to inflate. It is, then, their "primary goal to inhibit the next tech bubble".

With that goal in mind, the contours of the book make sense. The authors are building the strongest case possible against thoughtlessly integrating AI systems into our lives without considering the wide-ranging societal and personal consequences. But in building such a case, it can sometimes feel like they are constructing an AI straw man, and genuine academic inquiry into what these systems, at scale, might be doing is left out.

They spend a chapter looking at what these tools are, both more traditional AI systems and newer large language models (LLMs) that power services like ChatGPT, but their details are scant. They conclude that ChatGPT is nothing more than "souped-up autocomplete" and a "synthetic text extruding machine", and that it definitely isn't sentient.

But the argument over sentience, which many scientists would rightly scoff at, misses a more interesting discussion. It is still an outstanding research problem as to how LLMs can solve problems that would appear to require a form of reasoning, like genuine mathematical solutions, or real-world robotic control. In framing the debate around whether or not these machines are thinking like humans, they omit scientific research into how the scale of large systems can produce new, emergent capabilities as complexity multiplies.

This may not justify the current AI hype bubble, but it seems odd to ignore the reasons that many sensible people are excited about these models, and instead argue that AI should be restricted to narrow uses, like processing images for radiologists or checking spelling.

Despite this frustrating oversight, many of the arguments that Bender and Hanna make about AI's detrimental effects on society are compelling – and correct – regardless of whether you think these systems might be more powerful than they suggest. They rightly point out that the history of AI is littered with both overpromises and prophecies of doom, and that venture capitalists do see modern AI systems as a way to reduce jobs and increase profits for a select few.

These are all issues of genuine concern that are glaringly missing from discussions in governments and big tech boardrooms. But the increasing divide between AI evangelists and self-proclaimed neo-Luddites will be bridged only when both sides are honest about the true picture.

When presented in such a one-sided way, it isn't clear *The AI Con* will convince anyone who hasn't already made up their mind. ▮

New Scientist *recommends*

James Dinneen
Reporter
New York

I have spent too much time lately thinking about the network of fibre-optic cables that encircles the world. That's because these fibres are the subject of my new piece (see page 35), which explores how geoscientists are using them to map Earth's interior. Naturally, when I learned that Colum McCann's novel **Twist** is about this very network, I had to read it.

The novel follows a journalist on assignment to write about what happens when the cables that carry the internet under the ocean break. He boards a ship sailing to fix a cable off the coast of West Africa.

All the while, he struggles to understand the mission's leader, Conway, a taciturn freediver from Ireland with plenty of "missing years".

The plot is juicy and the writing lucid. But I most appreciated how McCann expertly transforms a horribly technical subject into a tale full of love and connection. "Everything gets fixed," says Conway. "And we all stay broken."

DAVID FLEETHAM/ALAMY

The sci-fi column

Going fully digital The premise of Grace Chan's debut novel – that you can choose to upload yourself to a virtual reality – might sound dated, but this is a quietly brilliant, big-picture look at a disturbing future for humanity, says **Emily H. Wilson**

Emily H. Wilson is a former editor of *New Scientist* and the author of the *Sumerians* trilogy, set in ancient Mesopotamia. The final novel in the series, *Ninshubar*, is out in August. You can find her at emilyhwilson.com, or follow her on X @emilyhwilson and Instagram @emilyhwilson1

ANDRIY ONUFRIYENKO/GETTY IMAGES

Would you leave a world wilting under a deadly sun for a digital utopia?

Book

Every Version of You

Grace Chan

Verve Books (UK, out now; US, 23 September)

Emily also recommends...

Book

Neuromancer

William Gibson

Ace Books

Gibson's debut still packs a punch. He is, after all, the person who popularised the word "cyberspace", and here he throws the reader into his vision of what cyberspace might be. A classic.

SCIENCE fiction that features characters who spend more time in virtual reality than in real life, whether via electrodes stuck into the backs of their necks or some kind of gloop-filled tank, isn't exactly a new thing.

In fact, picking up Grace Chan's *Every Version of You*, I worried that the premise of the novel – some young people in the future having to decide whether to permanently upload into a digital utopia called Gaia – felt a bit tired and dated.

Well, this book – first published in Australia in 2022, now available in the UK and coming to the US later this year – is neither tired nor dated. Chan manages to piece together a clever and thoughtful novel that sprawls out of its tightly observed, intimate beginnings into a big-picture look at humanity's future.

The book is set in Melbourne in the 2080s, and Australia has become dangerously hot. Indeed, the weather and pollution are so truly terrible that people shuffle around outside in heavy protective gear and must be decontaminated when they come home from even the shortest journey out. On the hottest days, all outside time is banned during certain hours, and consequently most people's lives are spent almost entirely indoors.

Inside their homes, with their robot cleaners doing the chores, most people (at least those who can afford it) choose to spend increasingly long stretches of time inside gel-filled tanks that give them access to the virtual world.

> **"Time in 'meat' world is spent maintaining the health of their bodies in the small amount of space they live in"**

Tao-Yi and her partner Navin are among those able to afford virtual reality; in one early scene, we see them brave the outdoor world to buy new, updated VR tanks for themselves. Back in the flat, they live a strangely skewed life. They spend most of their awake time in the tanks – they work in the spacious realm of virtual reality, as well as socialising there – while their time in "meat" world is largely spent maintaining the health of their bodies in the small amount of space they have to live in.

Right from the start, it is clear there are fissures opening up between Tao-Yi and Navin, although they are very committed to each other. For a start, Navin has serious medical issues and is often in pain. His time in VR, therefore, is a relief for him in a way it isn't for Tao-Yi. Secondly, Tao-Yi has stronger links to the physical world, starting with her mother, who isn't a fan of VR. But it's not just about her mother. Tao-Yi likes the smell of Navin; not the cottony scent the VR version of him offers her, but the real-life smell. The story is told through her eyes, and we watch as Navin throws himself ever further into virtual reality, while more and more questions grow in her mind.

Then comes a game-changing moment. Our heroes learn it is now possible to fully upload your mind to the digital world. Or rather, a copy of it. You can then live in the virtual utopia of Gaia forever, as an immortal. Meanwhile your real body is quietly rendered into dust.

What happens next, and the huge ramifications for the planet and humankind, are deftly handled. But we never lose our connection to Tao-Yi's gentle thoughts and feelings, and Chan manages to land the plot with what feels like authentic decisions for all concerned. The novel ends up managing to be about climate change, relationships, retreating into the virtual from reality, the future of human intelligence, how we change during our lives even without the help of VR, and a whole lot more. Bravo.

Editor's pick

Recognising animal culture is truly vital

5 April, p 36

From Maggie Wiśniewska, Shoreline, Washington, US

For decades, scientists searched for a bright line separating human culture from "mere" animal behaviour. The more evidence we get, the fainter that line becomes. When we insist on judging every other species against the single yardstick of human society, we reveal more about our biases than we do about other animals.

A good take on the issue is in the 1928 writing of US naturalist Henry Beston, who said that animals "are not brethren, they are not underlings; they are other nations, caught with ourselves in the net of life and time, fellow prisoners of the splendour and travail of the earth". Recognising those "other nations" and their diverse cultures isn't sentimental, but a step towards a fuller, humbler understanding of the living world we all share.

How about an old name for autism in women and girls?

Letters, 3 May

From Georgina Skipper, Wyke Regis, Dorset, UK

Several readers suggest coining a new name for autism in girls and women, given its differences to autism in boys and men. May I suggest an old one: Sukhareva's syndrome? Grunya Sukhareva's groundbreaking work on autism took place nearly 20 years before Hans Asperger's oft-cited work, and in the mid 1920s, she published a study into autism in young girls.

Government must explain its use of AI

3 May, p 12

From Harold Thimbleby, Cardiff, UK

You raise concerns over whether UK Prime Minister Keir Starmer is advised by artificial intelligence, as the government uses it to summarise documents and possibly to prepare draft briefings. Its excuse for denying your requests to tell us more – that reviewing and summarising over 13,000 prompts used to elicit AI outputs was impractical – is questionable.

The government could provide a random selection of prompts: 100 might be representative, and could be easily reviewed. This would fulfil the spirit of the Freedom of Information Act. Or another, perhaps better option would be for the government to use AI to summarise the 13,000 prompts. If it can't do this, surely it is no good at the job it is being used for!

An easier option than a radio dish on the moon?

26 April, p 38

From Garry Marley, Stillwater, Oklahoma, US

Your look at plans for radio telescopes and more on the far side of the moon, shielded from terrestrial electromagnetic clutter, was exciting. However, well before we commit resources to these endeavours, another short-term option is feasible. A radio telescope version of the James Webb Space Telescope, set in a synchronous lunar orbit over the far side, would yield similar data and avoid costly resources, human and robotic labour and that sticky dust encountered on the moon's surface. Lunar orbits up to 20,000 kilometres high are possible.

Generational differences writ large in car manual

19 April, p 19

From Shane Dywer, Melbourne, Australia

Excellent article on how every generation thinks they are smarter than the one before. I agree with all this, but was given pause for thought when I read a recent post pointing out that in 1925, car owners' manuals advised you how to adjust the engine's valves. In 2025, they make no mention of valves for a new generation, but they do advise you not to drink the battery acid. Good advice, I might add.

No decent climate TV, so try an opera instead

26 April, p 19

From Meredith Lloyd-Evans, Duxford, Cambridgeshire, UK

Bethan Ackerley asked for a climate change TV drama that can make a big impact. There may not be one, but there is Jonathan Dove's new opera, *Uprising*, inspired by Greta Thunberg's story. It has a tremendous impact that leaves many audiences and quite a few community chorus members crying at the end, including me when I sang in the bass section at a performance of it at Saffron Hall near Cambridge. It deserves to run and run.

I washed clothes in urine and they came out great

29 March, p 22

From Christopher Jessop, Marloes, Pembrokeshire, UK

Never overlook human urine's wonderful surfactant properties – the Romans certainly didn't when it came to doing their laundry. From my experiments, any textiles steeped at ambient temperature in a solution of fresh urine and rainwater (which is naturally soft) are cleaned amazingly well. After a cold rinse cycle, I couldn't detect any residual odour when pegging the clothes out.

Throw a handful of fresh lemon balm stems into your steeping bucket – and can anyone guess how the washing gets scented? As for disposing of the used solution: straight on the garden, of course. Its property as a wetting agent might deter, if not kill, aphids.

Post-war rationing diet was pretty healthy one

Letters, 26 April

From Sam Edge, Ringwood, Hampshire, UK

I agree with Paul Holt on the need to control for factors affecting dementia rates other than school leaving age before and after 1972. But I would be cautious before assuming that the older cohort who were born and brought up during rationing, and their mothers, were more likely to be malnourished. Many studies suggest that the UK rationed diet was healthier, with less meat, fat and sugar and more fruit and veg.

Wave or particle? There's only one way to find out

3 May, p 8

From Robert Masta, Ann Arbor, Michigan, US

Last year, Matt Strassler explained that particles are really a kind of wave (21 September 2024, p 32). Now, Celso Villas-Boas says that no, they are really just particles after all. Arguments are traditionally settled with a duel. Electron guns at 20 paces? Or a more modern cage fight, with the mesh replaced by diffraction slits? Or perhaps a surfing competition?

Thanks for the best fact ever for a chocolate fan

12 April, p 34

From Dave Shipley, Ottawa, Ontario, Canada

I learned from you that dark chocolate is high in fibre. That fact by itself has made this year's subscription worth the money. I salute you, Graham Lawton, with a square of 70 per cent cacao. ▮

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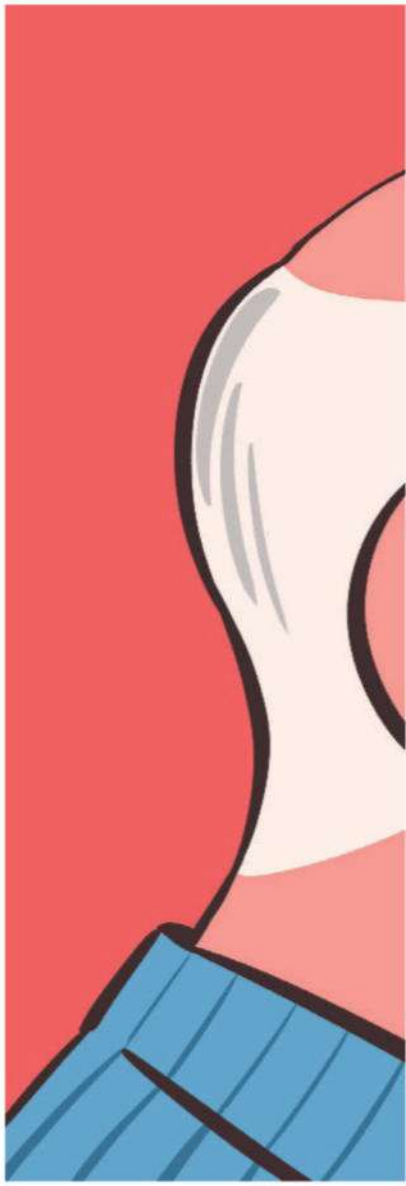


Your super sense

We often neglect our sense of smell, but honing it could keep you sharp as you age – and may even help reverse cognitive decline, discovers **David Robson**

I AM not normally a fan of lotions and potions, but right now, four small vials sit on my bedside table.

Every morning and every night, I open and sniff each one in turn, savouring the scents as they hit my nostrils. First, the sharp tang of lemon, followed by the abrasive chill of eucalyptus, the sweetness of rose and the metallic warmth of clove.

My new routine – training what is, for most of us, a neglected sense – was inspired by some striking research linking our noses' sensitivity to our cognitive performance. For one thing, studies have shown that the worse your sense of smell is, the worse you perform in cognitive assessments. Olfactory dysfunction has also been linked to more than 100 conditions, including ALS (motor neurone disease), multiple sclerosis, Parkinson's disease, Alzheimer's disease and general age-related cognitive impairment.

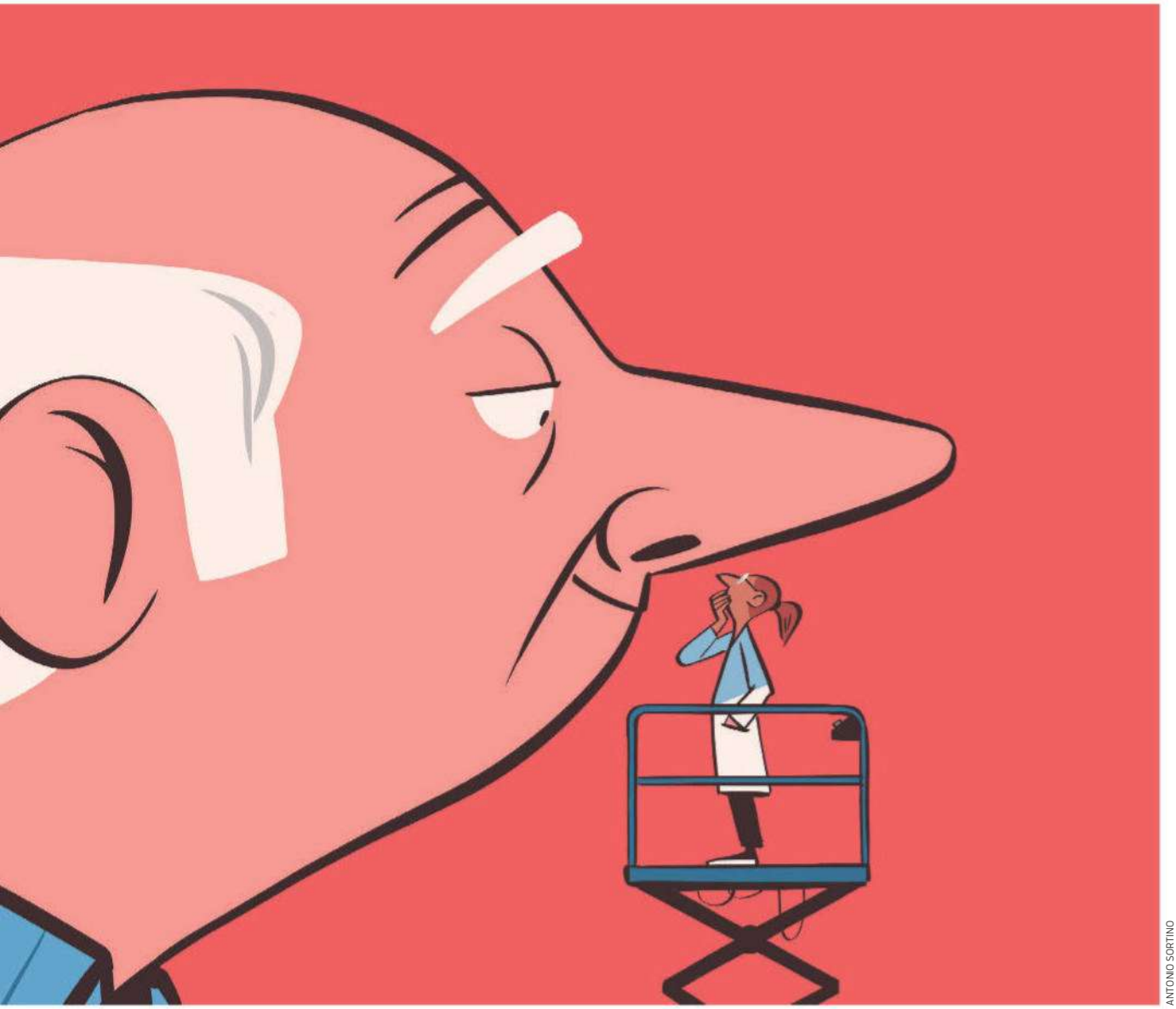
And though some of that olfactory impairment is undoubtedly the result of neurological damage, more recent research suggests that smell loss could actually contribute to some conditions. Failing the sniff test may even limit our overall lifespan – a frightening thought, given how many people lost their sense of smell as a result of the covid-19 pandemic.

"By middle age, your all-cause mortality can be predicted by your olfactory ability," says Michael Leon, a neurobiologist at the University of California, Irvine.

Evidence like that has prompted a host of investigations into whether "smell training" can reawaken this often-ignored sense and sharpen our minds. So far, research and real-world experience suggest that it can. Our olfactory ability seems to work like a muscle – the more we use it, the stronger it gets. "When you're confronted by the data, it's really hard not to be motivated to do it," says Leon.

Some olfactory impairment is, of course, unavoidable. Global rates of olfactory dysfunction are somewhat difficult to pin down – one pre-pandemic study of people in the US, for example, found that just over 12 per cent had some olfactory impairment, while a similar study of people in Sweden found that 19 per cent were dealing with some level of smell loss. Both studies, along with others, find that the incidence of olfactory impairment rises dramatically with age.

Like many people, I had always taken my nose for granted. I certainly didn't think I should be exercising it regularly to preserve its health. "In surveys, smell is always considered the least important sense," says Anna Oleszkiewicz, a psychologist at the University of



ANTONIO SORTINO

Wrocław in Poland. "People would rather give up on their smell than their smartphone."

Our lack of interest may arise from the persistent myth that human olfaction, the scientific term for smell, is simply less developed than that of other animals. This idea first emerged in the late 19th century, when neuroanatomist Paul Broca divided mammals into two categories – *osmatiques*, such as dogs, which are guided by their snouts, and *anosmatiques*, which aren't. The latter category included cetaceans – dolphins, porpoises and whales – and primates.

The mechanism of smell is roughly the same for all mammals: molecules enter the nose and dissolve in the mucus that coats the olfactory epithelium, specialised tissue in the nasal cavity that is densely packed with olfactory receptor neurons. The molecules bind to these receptors, which then send signals through the olfactory nerve to the olfactory bulb in the brain, the structure right above the nasal cavity where the scent is processed and identified.

Broca's principal evidence for his categorisation was variations in the sizes of that olfactory bulb. He had a point: after accounting for relative brain size, a dog's olfactory bulb can be 30 to 40 times larger than a human's, suggesting that scents play a much bigger role in canine lives. By the 1920s, scientists had started referring to smell as a "vestigial" sense in humans.

This notion went more or less unchallenged for a century, until modern researchers began putting the human nose to the test in the 2000s. Studies revealed that, with a healthy olfactory system, humans can detect many gases at extremely low concentrations – we need just a few molecules to reach the receptors in our nostrils. "Our sensitivity ›

"Olfactory testing could be useful in early screening for cognitive impairment"

Smell training in action
Watch David Robson explore ways to test and improve this neglected sense at **newscientist.com/video**

NEAR RIGHT: MARTIN PARR/MAGNUM PHOTOS; FAR RIGHT: PLATERESCA/GETTY IMAGES

is in a similar range to dogs, pigs and other animals that are considered 'super-smellers'," says Oleszkiewicz.

The oft-repeated wisdom that humans can discern only around 10,000 odours was also shown to be dramatically wrong. In 2014, researchers at Rockefeller University in New York used 128 odorous molecules to produce various scents to test whether participants could notice changes in composition. It turned out that they could do so to a remarkable degree; based on the participants' sensitivity to these different combinations of chemicals, the researchers estimated that the average person could differentiate among 1 trillion odours.

Unfortunately, many of us don't appreciate this rich "smellscape" until it is gone. The most common causes of smell loss are traumatic brain injury, viral infection and sinonasal disease. The olfactory epithelium and the nerves linking our nose to the brain are directly exposed to pollutants and pathogens, making them especially vulnerable to damage.

The results of that damage can be devastating. "You're encased in a bubble and the world is going on out there without you," says Chrissi Kelly, who lost her sense of smell in 2012 following a sinus infection. She soon fell into what she calls a "profound depression", a very common consequence of olfactory damage. "I felt like I'd undergone a personality change," she says.

Vanishing aromas

A low mood is a natural response to losing a sense that, whether we realise it or not, plays a significant role in how we experience the world. We may not recognise how important aroma is to the flavour of food, for instance, until it vanishes.

"Your day becomes a lot less colourful," says Thomas Hummel at the Dresden University of Technology in Germany. Hummel's research has also found how deeply olfactory dysfunction can affect people dealing with it: in 2022, Hummel and his colleagues tracked 171 participants with a damaged sense of smell over 11 months. They found a clear correlation between patients' olfactory ability and their depressive symptoms over this period – and when their olfactory function improved, so did their mood.

Olfactory dysfunction also appears to be connected to a host of other conditions that cannot be so easily explained, however. Reviewing the evidence, Leon and his colleagues recently documented 139 conditions associated with smell loss, including cardiovascular disease, arthritis, polycystic ovary syndrome and a host of neurological conditions, such as Parkinson's and dementia.

In many of these conditions, smell loss may be a symptom – high blood pressure might damage the vessels in our nose, for example. When it comes to dementia, however, the direction of causality is less clear, with a wealth of research demonstrating a strong link between olfactory ability and cognitive function.

Between 2011 and 2014, for example, the LIFE-Adult-Study in Leipzig, Germany, asked about 7000 participants to take various health assessments, including tests of their sensitivity to different odours, their capacity to distinguish between them, and their mental abilities.

A clear correlation emerged between the participants' olfactory capacity and their results on the cognitive tests, even after researchers adjusted for factors such as age, education and depressive symptoms – the weaker the nose, the worse participants scored in verbal fluency, attention, memory and learning. The results prompted researchers to suggest that olfactory testing could be useful in early screening for cognitive impairment.

Other studies have come to similar conclusions. In 2021, psychologists at San Diego State University in California examined the health records of 497 people. They found that people's performance on odour sensitivity and identification tests could predict who developed mild cognitive impairment and who developed Alzheimer's. Quite remarkably, the olfactory tests were shown to be a better predictor of the condition's progression than the Mini Mental State Examination, an assessment that is widely used to identify who is at risk of dementia.

Based on these findings, some researchers have come to suspect that lost smell sensitivity is actively contributing to the brain's deterioration. Leon offers two good reasons why.

The first concerns the brain's wiring. Vision, hearing and touch first pass through a neural relay station known as the thalamus, located deeper within the brain, before reaching the outer layers associated with higher-level thinking. "The thalamus is like a railroad hub," says David Vance, a psychologist at the University of Alabama at Birmingham. "Everything arrives there, then it's processed and distributed through the brain."

Smells, however, go straight to the olfactory bulb. Embedded in the forebrain, the bulb has direct links to many other areas of the cortex that are involved in emotional processing and regulation, decision-making, memory and learning, including the amygdala, the orbitofrontal cortex and the hippocampus. "The olfactory system is the only sense with a 'superhighway' to the memory centres and the emotional centres of the brain," says Leon.

This fast track to the cortex may explain why certain smells can be so evocative. And when that superhighway is broken, we lose a potent source of mental stimulation that would otherwise help keep our neurons happy and healthy.

Brain scans support this idea. Olfactory dysfunction is accompanied by a widespread loss of our brain's grey matter and the wiring that passes messages within it. As you might expect, the most pronounced changes can be seen in the olfactory bulb itself – but many other regions shrink alongside it, including the orbitofrontal cortex and the hippocampus. Such changes may explain both the cognitive decline and the rising depression in such

Pleasant odours, including lavender (right), have been shown to suppress inflammation

"The olfactory system has a 'superhighway' to the memory and emotional centres of the brain"

people: "Smell loss interferes with the affective and emotion control systems," says Hummel.

Leon's second hypothesis concerns inflammation. The body naturally raises inflammation to protect us from infection. If it remains too high for too long, however, it can cause damage to our organs – and is known to be a major risk factor for the development of Alzheimer's.

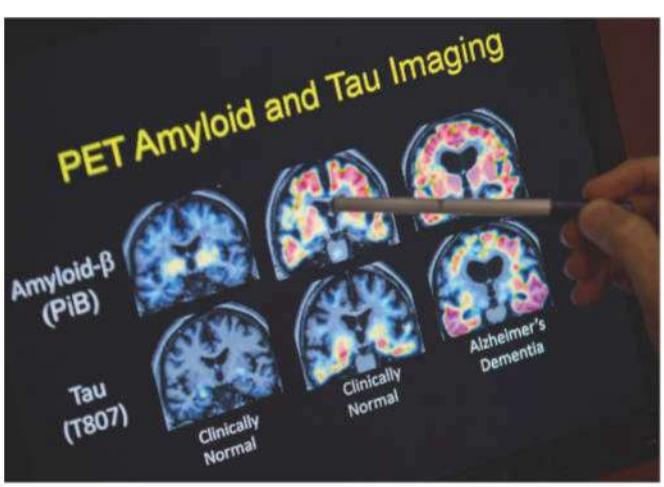
He points to evidence showing that certain odours can rapidly provoke the immune system. Mats Olsson at the Karolinska Institute in Sweden and his colleagues asked participants to sniff and then rate the chemicals that give rotten eggs, fermented herrings, urine and vomit their disgusting odours. Afterwards, they swabbed the participants' saliva and measured the levels of certain inflammatory molecules. The resulting paper, published in December 2022, showed a clear connection between the two: the fouler the stench, the higher the levels of inflammation, suggesting that the scents primed the oral cavity with a "preparatory immune response" to potential pathogens. Meanwhile, pleasant odours – such as eucalyptus, lavender, ginger, citrus and peppermint – have been shown to suppress inflammation, although exactly why is unclear.

A healthy nose may, therefore, help keep our immune system in check, raising inflammation when it perceives a potential threat to our health and lowering it when it senses we are in a safe environment. Olfactory dysfunction throws this out of balance, leading to chronically high inflammation that ultimately damages the brain.

The ability to smell our surroundings can also help us avoid environments that trigger inflammation. "Bad odours predict bad things and so it's a good idea to stay away from them," says Leon. If our noses lose their sensitivity, we may not be so good at making those calls, potentially increasing our exposure to pollutants and pathogens that might cause more damage to our nose and brain.

Animal studies are helping to pick apart these threads – and they strongly suggest that the olfactory system plays a crucial role in the development of dementia. Researchers at the University of Navarra in Spain, for instance, found that exposing mice that were genetically programmed to develop the equivalent of Alzheimer's to the sweet smell of menthol reduced brain inflammation and improved their memory. These benefits were completely absent, however, in animals with a damaged nasal cavity.

Mohammad Reza Raoufy at Tarbiat ›



AP PHOTO/EVAN VUCCI/LAMY

A declining sense of smell is linked with Alzheimer's disease

JIM DYSON/GETTY IMAGES

Bad odours are a warning sign to avoid what is producing them

Modares University in Tehran, Iran, and his colleagues also recently reported that electrically stimulating rats' olfactory bulbs can slow the accumulation of amyloid plaques, improving cognition and preventing dementia.

Could we achieve the same results simply by paying a bit more attention to our noses? That's the aim of various commercially available smell-training programmes. These kits usually require users to sniff a variety of aromatic compounds – such as clove, eucalyptus, rose and lemon – for a few minutes each day, over a few weeks or months.

There is good evidence that smell training of this kind can improve olfactory abilities. "When we expose ourselves to odours, we become more sensitive," says Hummel, who pioneered studies into smell training. In 2009, he and his colleagues recruited 56 people with olfactory dysfunction. Forty were assigned smell training over 12 weeks, during which they were told to sniff each of the four odours described above for at least 10 seconds twice a day and to keep a weekly diary of their experiences. "If you ask people to do something on a routine basis, it needs to be super simple," says Hummel. Despite this very low time investment, subsequent tests revealed increased odour sensitivity, while a control group saw no change.

Other, subsequent trials suggest that patience is key. A 2016 study of people with post-infectious olfactory dysfunction, for example, found that more than 70 per cent of people who trained for 56 weeks experienced significant improvement, compared with 58 per cent of those who trained for 15 weeks.

Crucially, the training also brings a brain boost. Vance and his colleagues recently reviewed the evidence for smell training's effects on mental performance, finding 18 controlled trials that offered promising evidence that it really can slow or even reverse some signs of cognitive decline. A few of these experiments also revealed neurological changes, including growth in regions like the hippocampus. "Neurons that fire together, wire together," he says. "So you have all that neuroplastic input that creates a lot of changes in the brain."

"A healthy nose may help keep our immune system in check"

We may not even need to be awake to reap the benefits. Leon recently invented a commercially available device called Memory Air, which puffs out 40 different scents as the user sleeps. A small trial that tested an early prototype on 43 people aged 60 to 85 found a 226 per cent improvement in verbal memory after six months of nightly use. "There have been billions of dollars spent on trying to find ways to improve memory, and it turns out that you can improve it with just giving olfactory enrichment," says Leon.

In trying to regain her lost sense of smell, Kelly trialled an experimental treatment that involved injecting blood cells called platelets into her nose to help regenerate the tissue. The platelet injections did improve her sense of smell slightly, she says, but consistent smell training had already helped return some of her lost sensitivity: "Smell training and smell awareness is a constant part of my daily life, and I have no doubt that it has played an important role."

The restoration of her sense of smell hasn't just recoloured Kelly's world; it has brightened and enlivened it. "Once you are in the habit, your world is so full," she says. "Everything in your house smells. Every book has a different smell, your tea towel, even your keys." In line with the scientific research, this has enhanced her sensory memory, says Kelly. "It's like getting into Narnia, you know? You walk into the wardrobe, move the coats out of the way and pretty soon, you can feel the snow crunching under your feet." Based on her experiences, she has founded the CKOS Network, an online community for people with smell loss.

It was Kelly's experience that finally convinced me to give smell training a go myself. When I looked back on my childhood, I realised that smell was as vivid as any other sense. Cut grass, wet earth, the instant coffee I'd sprinkle on top of my hot chocolate – I lived in a vibrant smellscape. As the years have passed, however, my sensitivity seems to have waned, and I notice odours less and less. It is as if my world has moved from multicolour through to greyscale – and that doesn't bode well for my brain as I enter my fifth decade.

I purchased my vials of lemon, clove, eucalyptus and rose online and now sniff them in both the morning and evening.

After a few weeks, I've already noticed more flashes of odour entering my consciousness in the hours between each exercise, a glimpse, I hope, of a richer – and smellier – future. ▮

David Robson is an award-winning science writer. His latest book is *The Laws of Connection: 13 social strategies that will transform your life*

Earth song

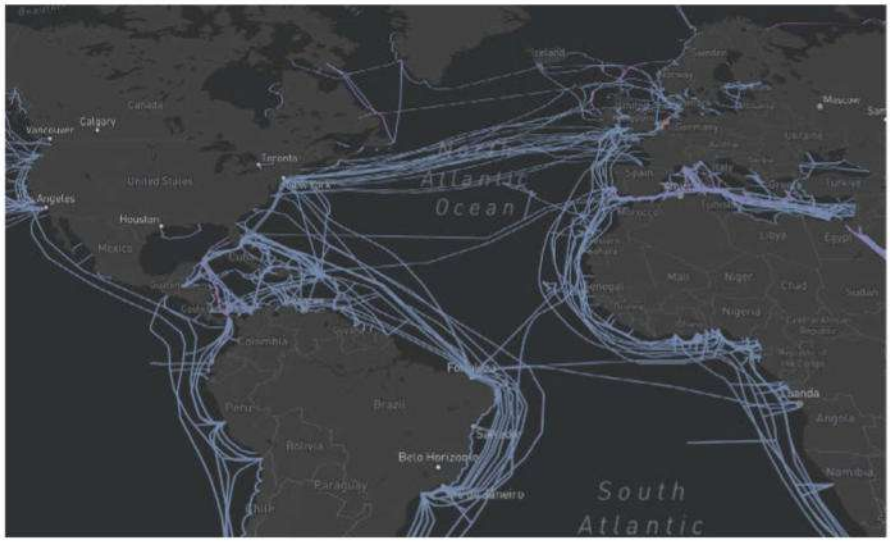
Buried cables are letting us listen in to subtle underground vibrations, revealing Earth's interior in incredible detail, finds **James Dinneen**

BENEATH the winding streets of Istanbul, Turkey, a fibre-optic cable pulses with laser light. Until recently, this stretch of the information superhighway has lain dormant and dark, but a group of researchers now huddles around to watch a computer screen fill with shimmering lines of data as the light flashes underground. The lines represent subtle underground vibrations from an earthquake, detected along the fibre in a way that has only recently become possible – part of a decades-long quest to peel back the surface of Earth and look inside.

Much of the internet, phone systems, television and other high-speed communications relies on a world-girdling network of fibre-optic cables. By one estimate, more than 4 billion kilometres of such cables snake beneath and between cities; the longest ones span oceans. Normally, we don't think much about this physical network, happy just to receive the calls, web pages and cat videos it transmits. But more and more, the cables themselves are becoming a valuable source of information about the planet.

In Istanbul, these fibres have revealed potentially life-saving information about how to protect people and infrastructure against future earthquakes. Elsewhere, they are allowing researchers to measure the subsurface hum of London's bustle, track the rumbling of Iceland's volcanoes and map the upper reaches of our ›

JULIEN PACAUD



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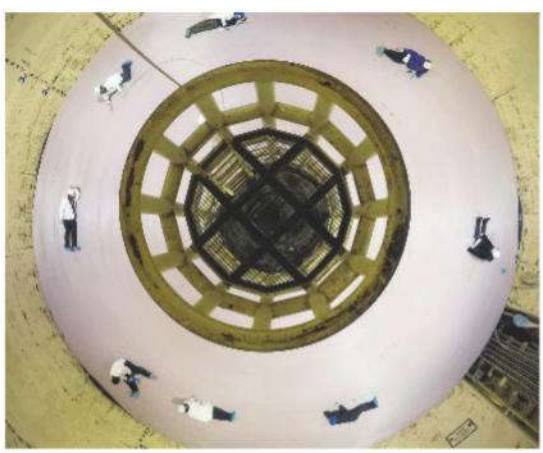

NEW YORK TIMES/REDUX/EYEVINE

Fibre-optic cables criss-cross Earth, including under the sea (above), where huge spools are laid from ships (left)

planet's mantle. This new view of the underground has the potential to transform our understanding of the world's constant vibration. "The overall goal is an almost transparent Earth," says Jonathan Ajo-Franklin at Rice University in Texas.

The road to that point begins with firing rapid pulses of laser light down a fibre-optic cable. For normal telecommunications, the aim is to send information encoded in these pulses that will be decoded on the other end – the cable is just the conduit. But the light can also be used to detect changes within the cable itself: if you were having a phone call or video chat over a fibre-optic cable and an earthquake occurred in the area of that cable, the frequencies in the other person's voice would come through distorted.

These distortions happen when underground vibrations stretch and bend the fibre through which a call is being carried. The warping in the fibre causes subtle delays in the light that is reflected back to the beginning of the cable by tiny imperfections in the glass it is made of, known as the backscatter. A device called an interrogator interprets shifts in this backscatter to determine exactly where the vibrations strained the fibre and by how much, which researchers use to reconstruct the tremors themselves.

A little more than a decade ago, seismologists realised they could repurpose fibre-optic cables to monitor underground trembling. This would be a cheap way to extend the coverage of existing networks of seismometers, which are expensive to install and operate. The high spatial resolution achievable with fibre optics could also create a far more detailed picture of the subsurface – at least at shallow depths – than what we can achieve with seismometers measuring shaking at a single point.

This gave rise to the field of distributed acoustic sensing (DAS), referring to how the cables make it possible to measure acoustic waves at many points along their length. The oil and gas industry pioneered the use of DAS; as early as 2009, the industry was testing ways to monitor shaking in wells by snaking a fibre-optic cable down with the drill. The approach was soon adopted for a broad range of applications, from tracking the movement of animals by their footsteps to observing changes in soil moisture by measuring the speed of waves moving through the ground.

"You have a new hammer, you have to go for every nail you can possibly find," says Andreas Fichtner at ETH Zurich in Switzerland.

Much of the research up to this point has used dedicated cables installed specifically for monitoring purposes. For instance, fibre optics are commonly installed to monitor infrastructure like pipelines and train tracks. But more ambitious projects have sought to exploit fibres in existing telecommunication networks. This approach has major practical benefits: it is cheaper because there is no need to build anything new, and existing networks cover far more of the planet than could ever be monitored with traditional seismometers. Cables that are actively carrying signals generally can't be used to take reliable measurements, because the DAS lasers tend to interfere with the other signals being sent, but there is another option.

Most telecommunication networks are replete with unused cables laid down in anticipation of future traffic. Making use of this global network of "dark fibres" could help fill the gaps in existing arrays of seismometers, says Andreas Wüstefeld at the NORSAR seismology foundation in Norway. While that includes hard-to-reach places like the bottom of the ocean, the locations that stand to gain the most are seismically active cities that lack robust systems to monitor for shaking.

Istanbul is one of the largest such cities, among the world's most seismically vulnerable places. That potential danger became tragically clear in February 2023, when a series of powerful earthquakes shook southern Turkey and Syria, killing more than 55,000 people and destroying hundreds of thousands of buildings. Istanbul, more than 800 kilometres from the epicentre, wasn't damaged, but low-level shaking did reach the city. By chance, a group of researchers led by Fichtner was recording on a dark fibre when the shock wave arrived. "As soon as we heard about it, we immediately rushed to the laptop and opened the data," says Daniel Bowden, also at ETH Zurich.

The timing was lucky: just three days prior to the quake, the team had started to monitor an 8-kilometre dark fibre running beneath several densely populated neighbourhoods. It was part of an effort to map the risk of earthquake damage across part of the city by recording the

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ambient vibrations from ocean tides and traffic. "We can measure how fast the seismic waves propagate, and all of that helps us build a model of that top 50 to 100 metres," says Bowden. Before the earthquake, they managed to record enough shaking to map the area's geology in block-by-block detail.

This map showed that during an earthquake, some areas along the fibre could see 10 times more shaking than adjacent streets. The arrival of an actual earthquake enabled the researchers to validate their model results, supporting the idea that the dark fibres can reliably predict seismic risk. The city government of Istanbul now has that data to help inform building codes and construction projects above the fibre, says Bowden.

However, a single 8-kilometre fibre is just the start. The researchers are now expanding this approach across an entire city. In May, they began using four 50-kilometre dark fibres to map the ground beneath about 900 square kilometres of Athens, Greece. "We've never done something of this magnitude," says Fichtner. Together, the cables encircle Athens and cross it in a big "X", which should enable Fichtner's team to create a detailed, three-dimensional map of the ancient city's underlying geology and seismic risk. "For a seismologist, it's a dream geometry," he says. They will also test ways to monitor "microquakes" that could help forecast more dangerous shaking.

The devastating earthquake that hit southern Turkey in 2023 was picked up by fibre-optic cables under Istanbul

DALGIC/NURPHOTO/SHUTTERSTOCK

Rafael Mestre at the University of Southampton in the UK and his colleagues are preparing an even bigger project using a dark-fibre network linking Southampton, London and Cambridge. "Nobody has done large-scale continuous data acquisition in really large cities like this," says Mestre. These areas aren't prone to earthquakes, but the data could have a slew of applications, from identifying leaky underground pipes to assessing the stability of building foundations. Urban DAS could even detect vibrations above ground that penetrate Earth, like noise from a nearby airport.

This extraordinary sensitivity does bring up concerns about privacy and surveillance. The fibres are so sensitive that they could, in theory, be used to detect footsteps or even voices, says Mestre. "It's going to be used and people don't even know about it."

DAS is also not without its technical issues. Much of the early interest in the technique focused on monitoring earthquakes in real time. Unfortunately, the flood of extremely noisy data produced by the cables has made that idea look more challenging than researchers initially thought. "The data are very difficult. They're just a mess," says Fichtner.

The cables are also concentrated where people live, so aren't useful in remote places. And getting access from telecommunication companies and governments can be a headache, he says. "[But now] we are discovering what is doable, and what is not."

There have already been plenty of useful results. For instance, Ajo-Franklin's group used a dark fibre in California to map ambient seismic waves, which revealed a previously overlooked geothermal reservoir that could be tapped to generate electricity. Researchers at the California Institute of Technology used dark fibres around a volcanic system in Iceland to detect early signs of eruption. Another team, based at the University of California, Berkeley, has made progress using offshore fibres to show how monitoring earthquakes in ocean basins could shave a few seconds off warning times. Tsunami warnings could, in turn, improve by life-saving minutes.

Meanwhile, other researchers are using these networks to peer into the planet's depths. James Atterholt at the US Geological Survey (USGS) and his colleagues recently used a 100-kilometre dark fibre in California to map the boundary between Earth's crust and mantle in unprecedented detail. Known as the Moho line, this boundary occurs at varying depths across the planet and marks a distinct transition in the composition and properties of the rock as the crust gives way to the upper mantle. "Major structures that we see at the surface – volcanoes, faults – interact with the Moho," says Atterholt. Being able to monitor such deep interactions could shed light on how large an earthquake a fault might generate, or on the plumbing of a particular volcanic system.

Dark fibres

The USGS is now exploring ways to use a dark fibre in northern California to study one of the most seismically active areas of the continental US: a meeting point of three tectonic plates called the Mendocino Triple Junction. Monitoring shaking there could enable researchers to map this complex region in more detail, shedding some light on how it generates such powerful quakes. "It's really exciting to think about imaging the Earth at a much, much higher resolution," says Atterholt. "We're trying to use this fibre to do some interesting science."

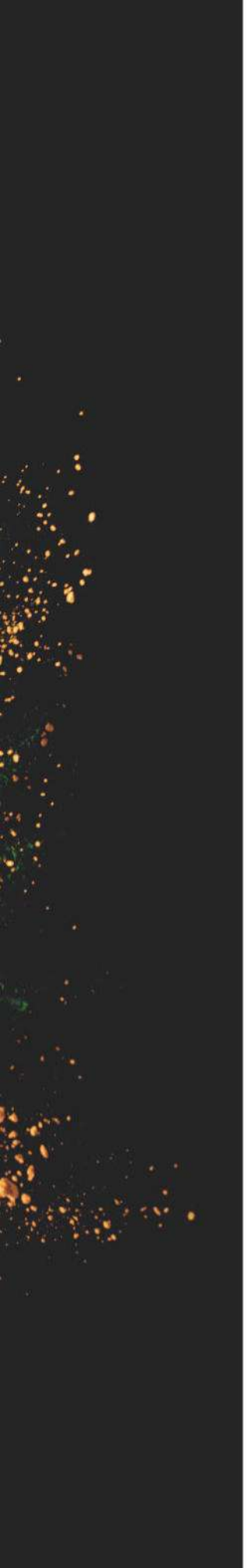
The potential may even extend beyond the network of dark fibres. Researchers have recently shown that it may actually be possible to reliably collect DAS measurements on "lit cables", those that are simultaneously transmitting other signals. This "multiplexing" approach works by carefully selecting the wavelength of laser light fired through a cable so that it doesn't interfere with other network traffic. This could make it possible to measure the vibrations on any part of the global fibre-optic network.

Measuring these quakes amid the signals of the internet could, in turn, expand our view into the planet's interior wherever cables are in place: under cities, beneath the oceans, all around the world. If it is possible, it could be a huge leap towards a truly transparent Earth. ▮

James Dinneen is an environment reporter for *New Scientist* based in New York

Smashing!

Reviving the ancient art of alchemy may sound unscientific, but grinding together dry powders is transforming modern chemistry, says **Hayley Bennett**



PEXELS

IMAGINE yourself in a chemistry lab. You are probably picturing a scene featuring a whole load of liquids – fluids bubbling in round-bottomed flasks, solutions swirling in test tubes, droplets running down condensers. It is a cliché, but one that accurately describes what these spaces have looked like for centuries the world over.

There isn't much frothing or bubbling going on in Tomislav Friščić's lab, though. That's because he and his team at the University of Birmingham, UK, are trying to do away with liquid chemistry. The tools of their trade are powerful machines like the ball mill, a grinder full of metal spheres that resembles a mini cement mixer. It may seem brutal, but this hardball approach could shake up the way chemists work, freeing them from the "mental prison", as Friščić puts it, of having to dissolve everything.

Chemistry creates many of the wonders of modern life, from the medicines that heal us to the screens with which we communicate. When researchers want to make these things from scratch, they often start by assuming they must dissolve their materials. But mechanochemistry, the burgeoning field Friščić is fascinated by, shows this isn't always necessary. "Mechanochemistry gives you the intellectual freedom to think: 'Let me just try this reaction by grinding it'," says Friščić. "And, in many cases, it works."

Now, a growing number of chemists are recognising the merits of this radically different way of doing chemistry. One prime benefit is that eschewing solvents could make the chemical underpinnings of society far more environmentally benign. So, could this radical idea catch on?

To be fair, chemists haven't always been so strongly tethered to solvents. The 1st-century Greek alchemists who made the red pigment cinnabar did so by simply grinding together mercury and sulphurous minerals. Apothecaries in the Middle Ages macerated plants to make medicines. But they may not have regarded this as chemistry, per se: scholars as far back as Aristotle often denied that force alone could cause chemical reactions between solids, arguing instead that heat or tiny amounts of liquid must be responsible.

In the late 19th century, US chemist and photographer Matthew Carey Lea realised that pressing hard on the silver compounds he used to develop his photos made them change colour, similar to how they did when they were exposed to light. In an 1894 paper, he noted that "very little, if anything, is known" about the relationship between mechanical and chemical energy. But he adopted the term mechanochemistry, coined by German scientist Wilhelm Ostwald two years earlier. After that, though, interest fizzled out. For much of the 20th century – with the exception of scientists in the Soviet Union – few paid attention to mechanochemistry.

Tyranny of liquids

Meanwhile, researchers were busy continuing to develop the recipes and rulebooks of wet chemistry. Making a drug or a fancy new material often involves stitching together different groups of atoms with fresh chemical bonds. At each stage, chemists dissolve the required ingredients in a solvent, usually heating them, then evaporate or filter away the solvent to get their product. Catalysts can be added too, to accelerate reactions. Working in this way has its advantages. Solvents help molecules to scoot around and crash into each other. They can be piped around and stirred, creating a more even reaction. And you can house them in glassware, making it easy to see colour changes or other signs of the otherwise imperceptible dance of the atoms.

But solvents also come with huge disadvantages. Plenty of carbon-based, or organic, chemicals won't dissolve in water, so chemists must use other solvents – things like chloroform, acetonitrile and tetrahydrofuran – many of which are toxic. Making and disposing of these solvents consumes huge amounts of energy and contributes to air pollution and climate change. Demand for the products that power modern life – medicines, cosmetics, cleaning products and plastics – means the need is vast. Global solvent production is forecast to reach nearly 33 million tonnes a year by 2026.

One answer is green solvents that are less toxic and made via less environmentally damaging routes. Another is to employ no solvent at all. And that's exactly what a new generation of chemists realised when they rediscovered mechanochemistry. In 2012, Friščić collaborated with Stuart James at Queen's University Belfast, UK, and others on a popular paper introducing the field and the opportunities it offered for cleaning up the chemical industry.

For James, it all started 20 years ago, when he was working in the fledgling field of metal-organic frameworks (MOFs). These ›

DR ANZE ZUPANC/UNIVERSITY OF BIRMINGHAM

A resonant acoustic mixing device gently jiggles powders together

crystalline, honeycomb-like materials, which have large pores surrounded by clusters of metal atoms connected with carbon-based bridges, are now finding applications in gas storage. Back then, it was taking chemists hours or days to make MOFs in "horrible" solvents, says James. But after hearing about mechanochemistry at a conference, he decided to give it a whirl. "I just thought: 'OK, we buy a little ball mill, put it in the lab, ask people to have a play with it and, you know, see what happens'," he says.

What happened was that the ball mill sat unused for a while. Then, one day, Anne Pichon, a student in James's lab at the time and now a senior opinion editor at the journal *Nature*, decided to try using it to make a particular MOF. This involved a reaction that could be easily followed by watching the colour change from green to blue. Pichon put two powders – a copper salt and an organic compound for making the carbon-based bridges – into the ball mill and whizzed them together with no solvent. Ten minutes later, to her surprise, the mixture was blue.

Since then, the team has installed an array of MOF-making devices, including "twin screw extruders", which are more common in plastics manufacturing. Speaking on a video call, James carries his laptop into the lab in search of an extruder, where he finds one that has been dismantled on the benchtop to reveal the key parts: two giant metal screws, each longer than his forearm. The screws rotate next to each other in the machine to mash materials together. In 2012, James founded a spin-off company now known as Nuada, which uses patented screw-extrusion techniques to make MOFs at the scale of kilograms per hour and is testing them as a way to filter carbon dioxide out of industrial waste gases.

Chemists have also used grinding techniques to produce co-crystals, which are composed of drugs weakly bonded to other molecules that improve their absorption in the body. But in truth, neither MOFs nor co-crystals are all that hard to create. Far more challenging are complex organic molecules – the sorts of things that make up the active ingredients of drugs – which often require a series of expertly designed reactions to ensure the right product comes out at the end. Yet those working with the tools of mechanochemistry now also have these tougher targets in sight. "What I believe is really exciting about mechanochemistry is that it can lead – and this sounds crazy – to a complete industrial revolution," says Friščić. "I think it could open the door to making targets which are more complicated and which are scalable."

> "It is enabling chemists to make molecules they found impossible to create using traditional means"

Most modern chemistry requires chemicals to be dissolved in liquid for reactions to occur

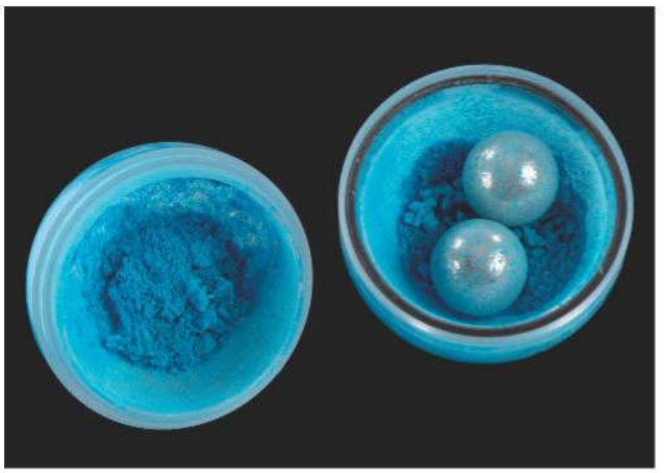
SIMONKR/GETTY IMAGES

Evelina Colacino at the University of Montpellier in France coordinates Impactive, a major collaboration that aims to use mechanochemistry to revolutionise how drugs are produced. She and her colleagues have made paracetamol (acetaminophen), and the anti-seizure drug phenytoin. In both cases, her team used milling to trigger a type of chemical reaction called a rearrangement, where a molecule reorganises its bonds and atoms into a new chemical structure.

Mechanochemistry is even enabling chemists to make molecules they have found impossible to create using traditional means. A 2022 review co-authored by Colacino cites multiple examples of the production of these "inaccessible" molecules. In some cases, ball milling got reactions out of compounds that chemists have struggled to dissolve – and which therefore have always been considered unreactive – including complicated, ring-structured chemicals called polyaromatics, which feature in cutting-edge electronic materials, among other things.

Meanwhile, Friščić, who has emerged as a key player in the field, is expanding his toolkit to help run mechanochemical reactions at larger scales. For this purpose, he is a big fan of resonant acoustic mixing (RAM), basically a mixer sitting on a vibrating plate that gently jiggles the reaction mixture rather than smashing it about with balls. "[RAM] was developed to blend," says Friščić. "And it turns out you can also mix substances this way to achieve a chemical transformation." It works best with a small dab of liquid, though far less than is used in traditional solution chemistry. Ditching the balls also means

"Mechanochemistry could lead to a complete industrial revolution"



BUNDESANSTALT FÜR MATERIALFORSCHUNG UND PRÜFUNG/BAM

A ball mill uses weights to grind chemicals together, making them react

it is simpler to separate out the products, and there is less chance of them being contaminated, for instance by flecks of metal chipped off the balls.

Friščić has used his shaking machines to scale up, by 200-fold, the synthesis of the diabetes drug tolbutamide. And, more recently, when he and his team made 10 grams a go of "exotic" covalent organic frameworks (COFs) – the more stable cousins of MOFs – they did it 100 times faster and with 20 times less solvent compared with traditional processes. Along with others in the field, they have also shaken up the iconic "click chemistry" reactions that have had a huge impact on synthetic chemistry by enabling molecules to be clicked together like Lego bricks. Friščić's team wedged a simple – and easily extracted – coil of copper inside the mixer to act as a catalyst, but another approach is to build custom mixers containing catalysts in the walls.

Yet if mechanochemistry is so brilliant, why aren't chemists everywhere running their reactions through ball mills? One reason is that it can be disconcerting for chemists to see reactions that may have taken hours or days in solution completed in 15 minutes with such devices, says James Batteas, who directs the Center for the Mechanical Control of Chemistry at Texas A&M University. When dealing with solutions, chemists can watch chemical changes happening or pipette out samples to check. But when the changes are reliant on molecules being roughed up inside an opaque metal box, that is far tougher. "It's not clear how the reaction is proceeding," says Batteas. And while chemists already have a good grasp of how bonds are made and broken in wet chemistry, mechanochemical reactions might be happening through completely different, unknown mechanisms.

With this challenge in mind, Batteas's colleague Jonathan Felts created a patented ball mill with integrated sensors to measure the forces required in test reactions. Work like this is also key to teasing apart the influence of physical force versus, say, increasing surface area during reactions. "This is where we feel it's very critical in order to be predictable, to understand these different effects," says Batteas.

Others are trying to get a better handle on the kinetics of mechanochemical reactions, or the rate at which reactants turn into products. Often, says James, these reactions start quickly and then slow, potentially due to changes in viscosity. "This isn't something you have to think about in solution-state chemistry," he says. "But if you've got two solids, sometimes you start with powder and you end up with [powder], but, in the meantime, it's gone through some weird, rubbery sort of thing."

Destructive in a good way

Ultimately, chemists crave a molecular-level understanding of what is going on. For this, they need techniques like Raman spectroscopy and X-ray diffraction (XRD) to peer into mechanochemical reaction mixtures and uncover the identities and structures of the molecules within. Friščić's team, for example, has used see-through milling jars to capture the signals of hard-to-pin-down compounds that form as intermediates during the synthesis of the sulphur compound thiourea, as well as modified XRD set-ups to pick up weird new MOFs formed during milling reactions. Combined with modelling, these techniques can help reveal the pathways that atoms take on their way to forming products.

As well as creating new chemicals, mechanochemistry can be destructive – in a good way. At Utrecht University in the Netherlands, Ina Vollmer's lab has been meticulous in trying to work out what happens when plastic waste is broken down in a ball mill. Vollmer came to mechanochemistry looking for a greener way to take spent plastics like polyethylene and polypropylene and turn them back into their chemical building blocks. "We were really thinking about it for circularity and recycling, to make these polymers again," she says.

Such chemical recycling is already possible, but it requires temperatures of around 300°C (570°F), meaning plastics are usually melted and reshaped instead. However, Vollmer's team recently succeeded at doing it at room temperature using an ingenious milling system in which the catalysts driving the reactions are stuck to the balls themselves. They can throw in pellets of plastic – from old garden chairs and toys, for example – and get out hydrocarbon gases like propene. According to Vollmer, the team is now building a bigger ball mill and founding a start-up to commercialise the process. It is a stunning example of what mechanochemistry can do, says Friščić.

Still, some chemists remain reticent about swapping their beakers for ball mills due to the outlay involved. With certain models costing north of £15,000, purchasing a ball mill could put a dent in funds earmarked for, say, paying laboratory staff. Friščić's answer to this dilemma is to make his university's new mechanochemistry centre open access. He plans to make it a demonstration station for chemists who will bring in their reactions to see what mechanochemistry can do with them, before investing in their own equipment.

One final hint that mechanochemistry is starting to hit the mainstream may lie in a simple symbol. When chemists describe their reactions, they do so with a system of diagrams and equations. In 2016, two chemists from Vanderbilt University in Tennessee proposed a symbol to signify mechanochemistry, one that is now increasingly popping up in reaction schemes in chemistry papers. It consists of three tiny circles, a nod to the trusty ball mill, and it means simply this: put your powders together and give them a good old shake. ▮

Hayley Bennett is a science writer based in Bristol, UK

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Mathematics of life

What a chore

Should you mow the lawn first or cut the hedge? A handy piece of maths can help with organising tasks, says **Peter Rowlett**

Peter Rowlett is a mathematics lecturer, podcaster and author based at Sheffield Hallam University in the UK. Follow him @peterrowlett

SCHEDULING household chores is hard. Say you have three loads of washing: a regular load that will take 110 minutes to wash and 120 to dry; a heavily soiled load that needs an extra 30 minutes to wash; and a sensitive one that will take 130 minutes to wash and 160 to dry. In which order do you wash them?

In the branch of applied maths known as operational research, this is called a two-machine problem. Lots of businesses have similar issues. One approach, to find the shortest overall time, is to identify the shortest step. If it is a wash, do that load first. If it is a dry, do that load last. This way, washing and drying the loads in the right order can save half an hour.

However, when I have a list of chores, it is often a set of tasks only I can do, making it a single-machine problem – I am the only "machine" that can process jobs, so every possible schedule takes equally long. The order is then irrelevant, in terms of saving time.

But there are occasions when factors other than saving time can still lead to an optimal task order for a single-machine problem. For these, we must consider what a "best" outcome is. Mathematically, what are we trying to optimise? We identify some measure that we are trying to make as large or as small as possible, given constraints.

For example, for tasks with due dates, you might simply do items in order of due date. If the grass needed cutting last week and the hedge only became due for a trim today, maybe cut the grass first. This is an attempt to minimise each item's lateness by completing the tasks that are most overdue, or closest to becoming overdue, first. It is why call centres put you in a queue in the order you rang.

JOHN MACLEAN/MILLENNIUM IMAGES, UK

Sometimes we have items that will expire by a certain date. What if you simply don't have time to eat all the food in your fridge? Do you try to minimise lateness, or minimise the number of items that spoil? The Moore-Hodgson algorithm works to minimise the number of late items. It sounds grand, but it is actually simple. First, we schedule items in order by due date. Whenever we get to an item where we will miss the due date based on this scheduling, we look back over the list so far and remove the "biggest" item from it (here, we choose not to eat the food that will take the most meals to get through). Then we repeat until we have considered all items.

Another factor can be priority: perhaps ordering a present for my son's birthday is very important right now, and doing the dishes can wait. To deal with this, we can give tasks a score (called a "weight"), divide it by the duration for each, and tackle those with the highest value first. In business, if the scores are the income gained by doing a task, this approach can be used to decide which jobs a company contracts to perform.

Now it just remains to decide whether to give ordering my son's present a higher or lower weight than making his tea. ▮

Mathematics of life appears monthly

Next week
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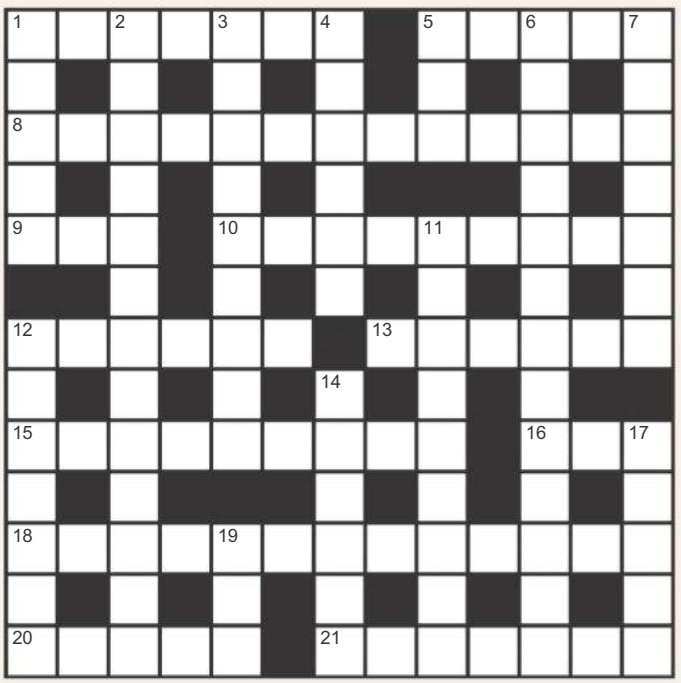

Scribble zone

Answers and the next quick crossword next week

ACROSS

1 What Indonesians might play, having strategy but no power (7)
5 Labour process is reportedly bunk (5)
8 It may warm up woman's voice-over, so lacking in animation (9,4)
9 Disturbance observed in radon nucleus (3)
10 Musical dances seen in Persian upbringings, perhaps (9)
12 Jabber, and irritate (6)
13 Key worker gets tipsy, unfortunately, after third of bottle (6)
15 Remastering some Clash can give you an indication of how hard rock is (4,5)
16 Rabbit in sack, turned over (3)
18 Ferry type needing deodorant (not fresh after dramatic part on radio) (4-2,4-3)
20 Endless column needs an edit – get stand-in! (5)
21 Soldiers, strung out, made new arrangements for transfer of power (7)

DOWN

1 Molten magma producing radiation (5)
2 "Clapham Cicero" ragged, being bigheaded (13)
3 John and Les consuming broth through helpful technicalities (9)
4 "Genesis Killer" promoted trendy supplement (6)
5 Sound of second-rate buzzer (3)
6 Take turns to gain access here (9,4)
7 Health and Safety (and Latin?) a part of telecommunication (7)
11 Young man having side dish with odd bits of chop taken out – it has to do with gas (6,3)
12 I, perhaps, in "platinum" era, luckily (7)
14 It's just a bit more (6)
17 Lie about identity, having two parts (5)
19 Love? His Majesty offers a measure of resistance! (3)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #303
set by Corryn Wetzel

1 Animals that like to eat primarily leaves are called what?

2 Which planet has the strongest magnetic field in the solar system?

3 What is the name of the colour people report seeing in total darkness?

4 Who developed the polio vaccine in 1955?

5 What is the name of the 4-point scale used to compare the pain of insect stings?

Answers on page 47

BrainTwister
set by Alison Kiddle
#74 Triple digits

Using the digits 1, 2, 3, 4, 5, 6, 7, 8 and 9 once each, create three numbers – each with three digits – and find their sum.

What is the smallest total it is possible to make in this way?

What is the second-smallest total?

Is it possible to get a total of exactly 1000? If not, how close can you get?

Solution next week

Fancy feast

When did hominids start to decorate their food and do any other species do the same?

Leo Coleman
Pratt Instituite,
Brooklyn, New York, US
The origins of this practice are probably unknowable simply because styles of food preparation are imperfectly preserved in the fossil record, as food is eaten or rots. Also, learning something about cultural life from human evolution is famously difficult, and always underinclusive since how we do what we do is shaped by history and custom as much as genetics. And while all animals process their food in some way, often elaborately (like honeybees), the practice is clearly more important for humans.

Adorning a pie with a fancy crust or scattering herbs about a piece of chicken are symbolic acts. People say something by ornamenting food, messages that only partly relate to the food itself. We could ask why our species evolved to be able to communicate about edibility, say, with symbols rather than simply "sensing" whether the food was good or not.

"Styles of food preparation and presentation tell us 'where we are', such as a birthday picnic or a wedding"

But symbols also lie – a fancy dressing can hide something rotten, and decorated food could harm rather than help survival.

One more philosophical answer to the question, then, offered by the anthropologist Claude Lévi-Strauss, is that preparing food helps us mark and manage differences between "raw" or "wild" nature and our own human condition of long-term dependence on others. Finally, all objects of human consumption are gathered, prepared and presented in some way, and how this is done helps us navigate our social world. Styles of preparation and presentation tell us "where we are" (such as a birthday picnic or a wedding), while also allowing us to play with these distinctions, such as serving humble food at a fancy event. As with all cultural practices, the question might not be, "when did this begin?", but "where does it take us?" And the possibilities are nearly endless.

Graeme Ruxton
University of St Andrews, Fife, UK
The only non-human example of food decorating that comes close to this that I can think of is nuptial gifts by male spiders. Quite a few spiders have evolved such that the male presents the female with a tasty fly, and she lets him copulate with her while she is feeding on it. In some of these species, the male goes to the trouble of wrapping the gift in silk. But I am not sure this is strictly food decoration – I think it is more about slowing her feeding down, so he has more time to copulate before she shoos him away.

My guess is that a similar situation explains the evolution of food decoration in humans. Feeding someone is a big part of courtship in a lot of human cultures. I think you will get brownie points from a potential partner for offering food that is something they are familiar with – and so feel comfortable eating – but with a little twist to make it look like you are making a bit of extra effort. So, scattering some flower petals on the steak that you present is bound to impress. I think one of the keys to this is that how we see food influences how it tastes to us – hence why there are games where we taste foods blindfolded – so decorating food might make the meal tastier and more memorable, which has to be good from a courtship perspective.

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This week's new questions

Flavour gap **Why do low and non-alcoholic beers taste so much closer to the "real thing" than non-alcoholic wines do?** ***Richard Blundel****, Oxford, UK*

Traffic toll **Does 34 years of mostly north-to-south traffic on a major bridge near me impact its stress levels or structural integrity?** ***John Stephen Rymell****, London, UK*

Why do non-alcoholic beers taste closer to the "real thing" than non-alcoholic wines do?

Seeing clearly

What difference would it have made to our species' technological development if glass wasn't transparent?

Pat French
Longdon-upon-Tern,
Shropshire, UK
As with any major innovation of long standing, we must assume that, in the absence of transparent glass, other avenues would have been explored to a similar degree for the various industries that employ glass today. Animal horn, hide, various crystals, paper and ice are materials that have been used where window glass was not available, and technologies might well have developed around these substances. Once transparent plastics started to become available, presumably much of today's technology would have followed or already been bypassed. Were the same resources invested in natural materials as have been allocated to glass and other ceramic research, who knows what might have emerged by now. One can imagine organic and crystal alternatives to glass lenses and fibre optics.

Opaque glass could still fulfil many of the functions of clear glass, if not always so conveniently. Presumably, it would still be possible to mould and blow opaque glass and it would still have its insulating properties. But gothic horror films would be very different without coloured liquids seen bubbling in flasks.

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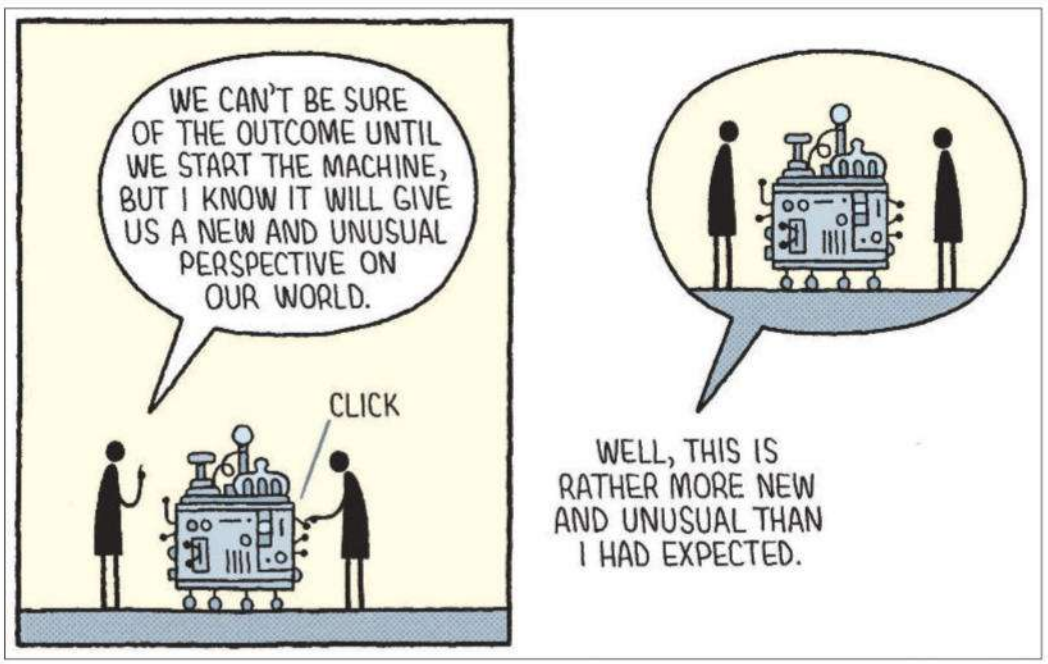
WE CAN'T BE SURE OF THE OUTCOME UNTIL WE START THE MACHINE, BUT I KNOW IT WILL GIVE US A NEW AND UNUSUAL PERSPECTIVE ON OUR WORLD.
CLICK
WELL, THIS IS RATHER MORE NEW AND UNUSUAL THAN I HAD EXPECTED.

Alex McDowell
London, UK
In a universe with no transparent material, lenses wouldn't be possible, and cameras would have to be of the pinhole type. Instead of corrective lenses, one could use "pinhole glasses" with lots of small holes in them.

The use of glass also revolutionised chemistry: chemists could use small amounts of reagents and see colour changes in test tubes. Before the advent of glass, they had to use cauldrons and large amounts of chemicals so that they could see colour changes. Glass has the advantage of being inert, but so do some metals, including gold and platinum.

Sam Edge
Ringwood, Hampshire, UK
Glass is used for many other reasons than its transparency. Some of its other useful properties are hardness and non-porosity when cold, ductility when hot, heat resistance, lack of chemical reactivity, longevity and surface smoothness.

"The use of glass also revolutionised chemistry: chemists could now see colour changes in test tubes"

These have led to its use for storage of things that must be kept clean and, in some cases, dry and even hermetically sealed. For this, transparency is sometimes convenient but not vital. Indeed, much glass used this way is merely translucent or even opaque to protect the contents from light damage. These properties also led to its use scientifically and industrially. While performing a laboratory titration might be tricky with a non-transparent burette or flask, heating a test tube over a Bunsen burner doesn't really require transparency.

Before the modern float glass process was developed, a lot of glass used for windows was less than fully transparent. Window glass is mostly there to allow natural light in and to keep the weather out without degrading. Windows as viewports to the outside are nice but not essential in most cases. Many other materials are translucent enough for this purpose. Paper was used for internal walls in many places, such as Japan, to provide privacy while still allowing light through. Paper can be waterproofed without becoming opaque, so it could be used for external windows as well, even in wet climates. Igloos are sometimes fitted with a window of thin, smooth ice that has formed on a water surface.

There are other naturally occurring and synthetic translucent and transparent materials, such as some plant fibres and thinly sliced woods, crystals such as quartz, polymers like Perspex and so on. Without glass, I imagine these would have been pressed into service, and their use refined. Without transparent glass, other solutions may have been discovered by necessity. ▮

Answers

Quick quiz #303 *Answers*

1 Folivores
2 Jupiter
3 Eigengrau
4 Jonas Salk
5 Schmidt sting pain index

Quick crossword #183 *Answers*

ACROSS 1 Malfunctioning, **10** Argon, **11** White heat, **12** Million, **13** Gang saw, **14** Neuro, **16** Rancidity, **19** Out-of-sync, **20** Excel, **22** Linocut, **25** Extreme, **27** Air pocket, **28** Omega, **29** Pterygoid plate

DOWN 2 Angel dust, **3** Fungi, **4** New energy, **5** Thing, **6** One in five, **7** Ileus, **8** Gateway, **9** Fat man, **15** Olfactory, **17** Nucleated, **18** Increment, **19** Oil lamp, **21** Lienal, **23** Nurse, **24** Tokyo, **26** Troll

#73 Square dance *Solution*

For the five tiles in the first square, the proportion of area used = (total area of small squares) / (area of outside square) = 5 / 9 = 0.556. For the others, use Pythagoras's theorem and the fact the triangles are all isosceles (with angles 90 degrees, 45 degrees, 45 degrees) to calculate the required lengths.

The side length of the second square would be 2.707, giving an area of 7.328, and the proportion used is 5 / 7.328 = 0.682.

For 10 tiles, you can imagine the central rectangle sliding diagonally until two corners touch the sides of the square. The side length of the square would be 3.707, giving an area of 13.743, so the proportion used is 10 / 13.743 = 0.728.

Egg versus ground

Feedback still gets pulse-raising flashbacks to the lockdown of early 2020, when we were home-educating Feedback Jr and consequently had to teach said child how to do things that we didn't ourselves know how to do. A substantial amount of time was consumed doing various science-themed activities, like looking for "mini-beasts" and setting up experiments, but at least we were spared the pain of the egg drop experiment.

This classic science practical challenges kids to design a device that will protect an egg from cracking if you drop it onto a hard surface from a specified height. Feedback would probably glue a cocktail umbrella to the egg, in the hopes that this makeshift parachute would slow its fall, then call it a day and go to have an actual cocktail. Others, however, take the egg drop experiment more seriously.

Hence the study published in *Communications Physics* on 8 May – although we note it was accepted on 1 April, which seems telling. Physics reporter Karmela Padavic-Callaghan describes the endeavour as "egg drop experiment but make it peer review".

The researchers "contest the commonly held belief that an egg is strongest when dropped vertically on its end". This refers to the conventional wisdom that, if you drop an egg with the blunt end down, it should be less likely to break, because the shell has more stiffness in the vertical direction.

By conducting "hundreds of experiments", supplemented with "static and dynamic simulations", the researchers determined that eggs are actually more likely to break if they land vertically, so you are better off dropping them horizontally.

They say: "Orienting the egg along its equator allowed it to reach 0.3 mm higher than in the vertical orientation without cracking, confirming a real albeit small advantage of dropping the egg along its equator."

If any readers are planning to throw eggs at any prominent public figures, you now have empirical guidance on how to ensure they break on impact.

Twisteddoodles *for New Scientist*

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Alien maths

Will we ever know what unidentified aerial phenomena (UAP), previously known as unidentified flying objects (UFOs), really are? Almost certainly not, according to a paper by Karim Daghbouche at German non-profit organisation GridSAT Stiftung.

Suppose you see a flying saucer or something else weird in the sky. You could use reverse engineering to work out what it is. By studying how it manoeuvres, you can make inferences about what kind of engine it has, and so forth. But, says Daghbouche, reverse-engineering UAPs is extremely difficult. Due to "the inherent challenges in data-gathering" and the possibility of "unknown physics", inferring anything concrete like "unconventional propulsion systems" will always be "computationally intractable".

In fact, says Daghbouche, the mathematical problem is so hard that it is "NP-complete": a maths term for a specific type of ultra-difficult problem. Worse, it "may escalate to PSPACE-hard or to an *Entscheidungsproblem*". The latter, for those not versed in this kind of mathematics, is genuinely impossible.

News editor Jacob Aron says, simply, "Incredible". Feedback is inclined to agree: if your set of possible explanations includes aliens with unimaginable technology, plus time travellers and visitors from alternative dimensions, it's going to be tricky to focus in on just one answer.

This might be another instance of a "no shit Sherlock", a scientific study that works through a great deal of complexity only to arrive at a blindingly obvious conclusion. But is it really an NSS if it's NP-complete?

Of course, one might consider the more human-centric explanations for UAPs, which rely on concepts like "honest mistake". In which case, the problem ceases to be NP-complete and becomes decidedly tractable.

Feedback was struck by the final line of the paper's abstract, where it says that, due to the difficulty of figuring out what they are, "UAP are as analogous to modern smartphones in the hands of Neanderthals".

Feedback is pretty sure that a Neanderthal would be able to figure out how to use an iPhone, and, for that matter, to develop a semi-sensible interpretation of UAPs.

Squared away

Since we're in a mathematical frame of mind, Brendan Ashe writes in to point out that we are in a square year: 2025 is 45^2. There won't be another one until 2116.

This reminded Brendan of a curious experience a few years ago. Enduring a long car journey, he and his son passed the time by googling famous people who were born in one square year and died in the next. There weren't many, but Russian neurologist Ivan Pavlov (of dogs and bells fame) "was born in 43 squared [1849] and died in 44 squared [1936]".

Then there came a dark twist. As Brendan relates: "We were also excited to note that Pope Francis was born in 44 squared, and I immediately foretold the Pope's death in 2025."

There is a special psychological hell for those of us who make a throwaway joke like this, only for it to come true. "Now my prophecy has been fulfilled, I can't help wondering how guilty I should feel," says Brendan.

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